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With the author's compliments.
V. K. Ting
Jan. 1920

WHANGPOO CONSERVANCY BOARD

SHANGHAI HARBOUR INVESTIGATION.

(SERIES I.—GENERAL DATA; REPORT NO. 1.)

REPORT

ON THE

GEOLOGY

OF THE

YANGTZE VALLEY

BELOW WUHU.

By V. K. Ting

U. S. GEOLOGICAL SURVEY
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GEOLOGY OF THE YANGTZE VALLEY BELOW WUHU

LIST OF ERRATA AND ADDENDA

Page 5, 4th line from top, read "were" for "are."
„ 9, 2nd „ „ „ „ "Ch'anghsing" for "Changhsing."
„ 13, 20th „ „ „ „ "squamata" for "Squamata" and "caligramma" for "Caligramma."
17, fig. 5, „ "porphyry for "prophyry"
19, 18th „ „ „ „ "Gebirge" for "Geberge"
21, fig. 9, read "Fig 10" for "fig. 9."
22, 21st line from top, read "Frech" for "Fresh."
23, 1st „ „ „ „ " „ „
23, 18th „ „ „ „ " „ „
24, 7th „ „ „ „ "Sandstone" for "Standstone"
24, 31st „ „ „ „ "sheet 52)" for "sheet 52,".
26, 8th „ „ „ „ "Ferruginous" for "Ferrugenous"
„ 29, 10th „ „ „ „ "(60 M ±)" for "(60 M +)."
„ „ 18th „ „ „ „ "On the east" for "on the east"
„ 32, 1st, 16th & 20th „ „ "plain" for "plane."
„ „ 27th „ „ „ "Chinkiang" for "Chinking"
„ 33, 20th „ „ „ omit "porphyritic"
„ 33, 29th „ „ „ „ "Rhyolites" for "Rholites"
„ 35, 1st „ „ „ omit " . " after "probably"
„ „ 6th „ „ „ omit "porphyritic"
„ „ 25th „ „ „ read "dopatic" for "depatic."
„ 39, fig. 22, read "structural axis of the mountain range" for "axis of seismic field." The N.E. part of the "arc of Huoshan" outside line V. should be omitted in the figure.
„ 42, 19th line from top, read "have never been" for "have been."
„ 47, 18th „ „ „ „ "his "Letters"" for "this "Letters"".
„ 48, 12th „ „ "it rather consisted of" for "it stood well out"

Page 48, 13th line from top, read "had been cut down to an almost even surface" instead of "were cut off to a firm completely even surface"

„ „ 14th „ „ "in the erosion of the" instead of "as an"

„ „ 20th „ omit "width"

„ „ 21st „ read "any interruption" instead of "an interruption"

„ „ 22nd „ „ "its angle" instead of "the dip"

„ „ „ „ „ "rock" for "stone"

„ „ 23rd „ „ "foot of the mountains" for "foot of the hill, islands"

„ „ 34th „ „ "the terraces are never" instead of "is never"

„ 51, 11th „ from top, read "嘉興" for "嘉與."

„ 51, 17th „ „ „ „ ",of course," for "of course"

„ 64, 2nd „ „ „ „ "town of Tungpa" for "town to Tungpa"

„ „ 15th „ „ „ „ "that on the west side is" for "that is"

„ „ 21st „ „ „ „ "the east side is" for "the east side it is"

„ 66, 8th „ „ „ „ "in that one" for "in one"

„ 67, 26th „ „ „ „ "into" for "in to"

Page 79, 9th line „ „ read "land building" for "deposition"

„ „ add Footnote:—

"Since this has been written my attention has been drawn to the discovery of a marine species of Crustacean, *Rhynchoplax introversus*, in the T'aihu Lake. This is certainly a survival of the time when the T'aihu Lake was part of the sea, and forms a remarkable confirmation to the views expressed above. See records of the Indian Museum, Vol. VIII, part IV and V, 1917."

Page 80, 15th line from top, read "very young age" for "extremely small age."

„ „ 32nd „ „ „ „ "(Fig 30)" for "Fig 30."

PREFACE.

IN the course of the first investigation which was made on the Yangtze Estuary in 1915-1916, it rapidly became apparent that geological factors entered largely into the problem, particularly in regard to the questions of subsidence, advance of the coast line, the progressive silting of the lakes and the development of the Whangpoo. The evidence for the extent and rapidity of these processes was obviously to be obtained quite as much from geological research as from hydrographic analysis.

In January 1917, I therefore approached Dr. J. G. Andersson, the Mining Adviser to the Nung Shang Pu (Ministry of Agriculture and Commerce) as to some assistance in this direction and he strongly recommended Mr. V. K. Ting, B. Sc., Director of the Government Geological Survey, for this purpose.

The following report is the result of Mr. Ting's work and amply corroborates my expectations as to the importance of the geological factors in the problem. The first part of the investigation, relating to the formation of the strata in and beyond the Hangchow-Chekiang hills, throws considerable light on the "tectonic" forces which have, in combination with the more subtle processes of denudation by wind and water, formed the coast. This somewhat technical and apparently irrelevant matter is absolutely necessary as a foundation for the subsequent consideration of the formation of and the current changes in the Delta.

The collaboration from this office has chiefly consisted in the compilation of the geological maps submitted by Mr. Ting, the collection of local rock specimens and the search for and perusal of the scanty technical literature on the subject. I am indebted to Dr. H. Chatley for assistance in this respect, his intimate acquaintance with the areas between Wuhu and Nanking being particularly serviceable. Mr. P. T. Zing and Mr. S. C. King should also be mentioned in connection with the map work.

H. VON HEIDENSTAM,
Engineer-in-Chief.

I wish to express my thanks to Mr. von Heidenstam and his colleague, Dr. Chatley, for their sympathetic interest and kind help. I am also indebted to my colleagues, Dr. J. G. Andersson and Dr. W. H. Wong, for their suggestion and criticism. Many other members of Survey have helped me; Messrs. Y. Y. Li, S. K. Keng, and P. Y. Tung prepared most of the illustrations, and Mr. B. F. Li compiled a glossary of place-names.

V. K. TING,

Director Chinese Government Geological Survey.

AUTHOR'S PREFACE.

IN the beginning of 1917 Mr. H. von Heidenstam approached the writer through Dr. J. G. Andersson, Mining Adviser to the Chinese Government, with the request to report on the geology of the Whangpoo and the Yangtse Estuary. As the known data on the subject are somewhat fragmentary and uncertain, I proposed that a rough geological survey should be made, and formal permission from the Ministry of Agriculture and Commerce was obtained. I was fortunate enough to secure the assistance of Mr. L. F. Yih, junior geologist to the Geological Survey, who was working in Chekiang at the time, and it was planned to start work in March. I was, however, unexpectedly called away to Kiangsi and Mr. Yih was left alone to work in the region between Chinkiang and Nanking. When I returned from Kiangsi, the hot season was already well advanced, and the political condition became also unfavourable, so it was agreed to postpone the work till the autumn. According to this arrangement I left Peking at the end of September, 1917, and went from Shanghai to the well-known summer resort of Mokanshan (莫干山) in Chekiang and hence to the coalfield of Kuangte (廣德) in Anhwei overland. After passing through the district of Chienp'ing (建平), I entered Kiangsu again by way of Tungpa (東壩), the famous barrier in Kaoch'un (高淳). Then Lishui (溧水), Liyang (溧陽), Ihsing (宜興) and Soochow were visited in succession and the neighbouring hills studied, including the celebrated Maoshan (茅山) range.

The following summary account is based on the study thus made and a report made by Mr. Yih on the hills between Nanking and Chinkiang and the coalfields of Changhsing (長興), as well as some material gathered in my earlier journeys in Southern Anhwei and Chekiang. I have had access to practically all the existing literature on the subject including the Japanese book on the Yangtse Valley and the newly published work on the Geology of Southern China. No literature list has been given because all the useful books consulted have already been acknowledged in the foot notes.

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Sinking:—Evidence of Sinking—Extent and Rate of Sinking—Effect of Sinking.

IV. THE HISTORY OF THE YANGTZE ESTUARY:

Theory of Ancient Mouths:—The Text of Yükung—Commentaries—Views of Edkins and Richthofen—Observation from Chienp'ing to Yushan via Tungpa—The Two Barriers—The History of Chungho and the Barriers—Explanation of the Three Kiang.

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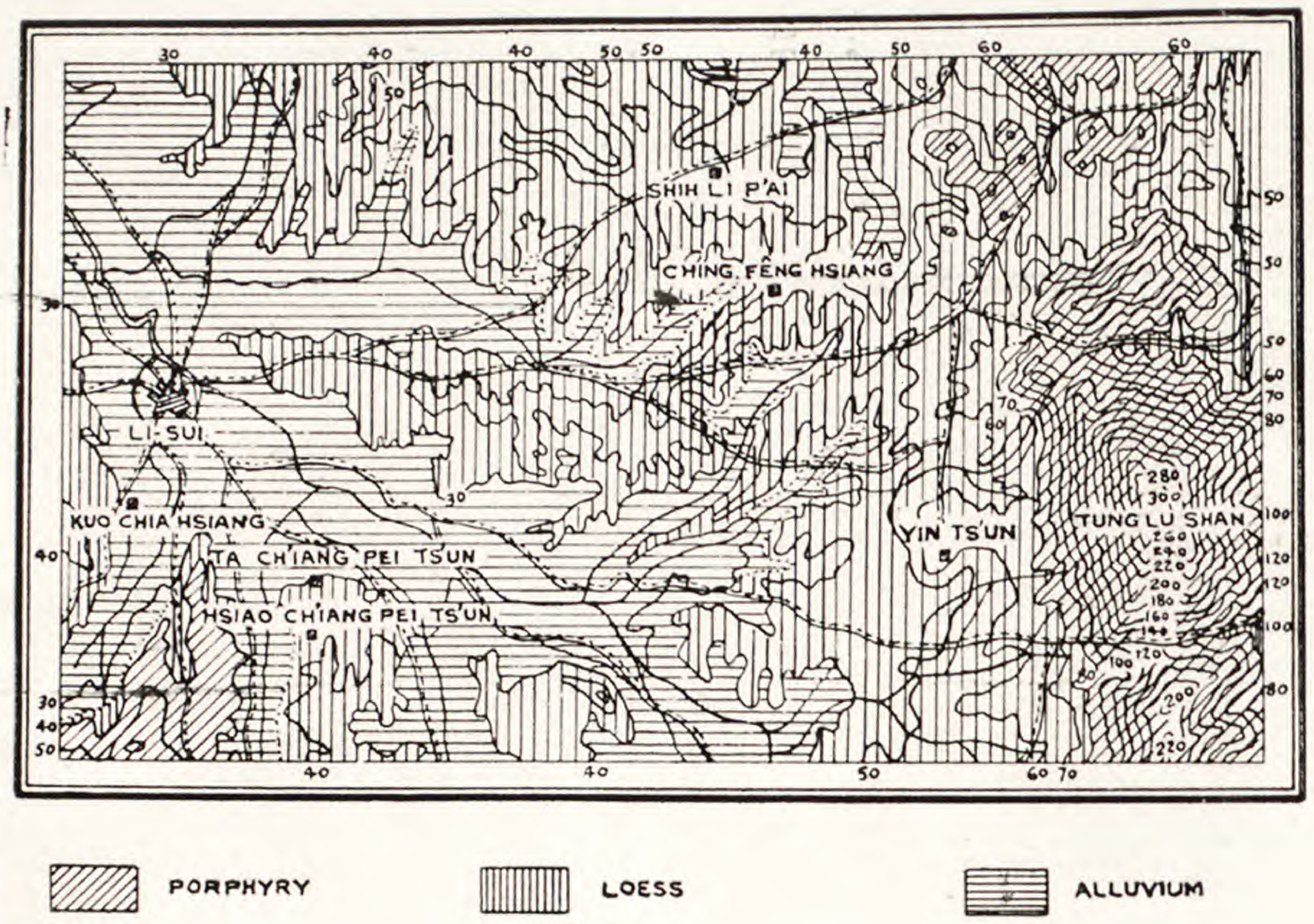
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PLATE II.



Geological map of Li Shui, illustrating Loess Terraces. Topography after the detailed Military Surveys made by the Chinese General Staff.

Scale 1 : 100,000

THE GEOLOGY OF THE YANGTSE VALLEY BELOW WUHU

I. STRATIGRAPHY.

The formations which we studied in the Yangtse Estuary range from Silurian to Quaternary. The former system, being the lowest visible, is limited to a few localities near Chinkiang. The exact age of the entire series is still uncertain, so we propose to apply to it the term Sinian in the sense in which Bailey Willis used to describe the Cambro-Ordovician system of N. China. The rocks above it are chiefly quartzite and sandy shale which have an extensive distribution, but their age cannot be more exactly defined than Middle Palaeozoic. Then follows the Carboniferous system with its rather complicated subdivisions the upper part of which may be Permian. No Mesozoic formation has been identified with certainty. The more recent rocks are conglomerates, loess, basaltic lava, and alluvium which vary between Tertiary and Quaternary in age.

Sinian.

THE LUNSHAN (嶺山) LIMESTONE: §

In the hill of Lunshan, some 25 kilometres S.W. from Chinkiang and 12 kilometres S.W.S. from Kaotse (高資), occurs a series of limestones, forming the greater part of the hill, in which Richthofen §§ found some fossils. These were studied by Frech §1. who distinguished the following species:

Asaphus sp. *Endoceras duplex Wahlenb.*
Orthis Squamata v. Pahlen *Orthis cf. Calligramma Dalm.*

The upper part passes into a calcareous shale containing doubtful graptolites. Although these fossils were rather badly preserved, Frech considered them to be Lower Silurian, i.e., Ordovician. Mr. Yih who revisited this locality from the north east end, found that the system consists of somewhat thick-bedded limestone varying from white to brown in colour, striking N.E.—S.W., dipping 45° S.E., much as Richthofen described; the total thickness being about 320 metres. A hurried search failed to find any fossils and the calcareous shale seems to be also absent at this end of the hill. He intended to return to make a more thorough search, but was unable to do so. In the three isolated hills to the north of Lunshan and south of Shanmienshan (扇面山), where Richthofen coloured as granite, Mr. Yih found another series of massive greenish limestone with a band of fine

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§. Here as well as elsewhere, where reference is made to the Nanking and Chinkiang Hills, See fig. ~~26~~ 25.

§§. China III p. 718—719.

§1. China Vol. V. p. 2.

grained sandstone and sandy shale interbedded. This is 110 M. thick and has the same strike and dip as the Lunshan limestone, so it belongs apparently to a lower horizon. The Shanmienshan itself is composed of limestone identical with that of Lunshan, but dipping in the opposite direction under the quartzite. Between this and the greenish limestone there is perhaps a fault. Assuming that the beds under the valley floor between Lunshan and the greenish limestone hill have the same dip, we find the rocks thus hidden ought to be 420 metres in thickness. Thus:—

Lower Silurian (— Ordovician)	Graptolite shale	?
	Lunshan limestone	210 M.
Interruption.....		420
Cambrian?	Greenish limestone S. of Shanmienshan	110
Total.....		740 metres.

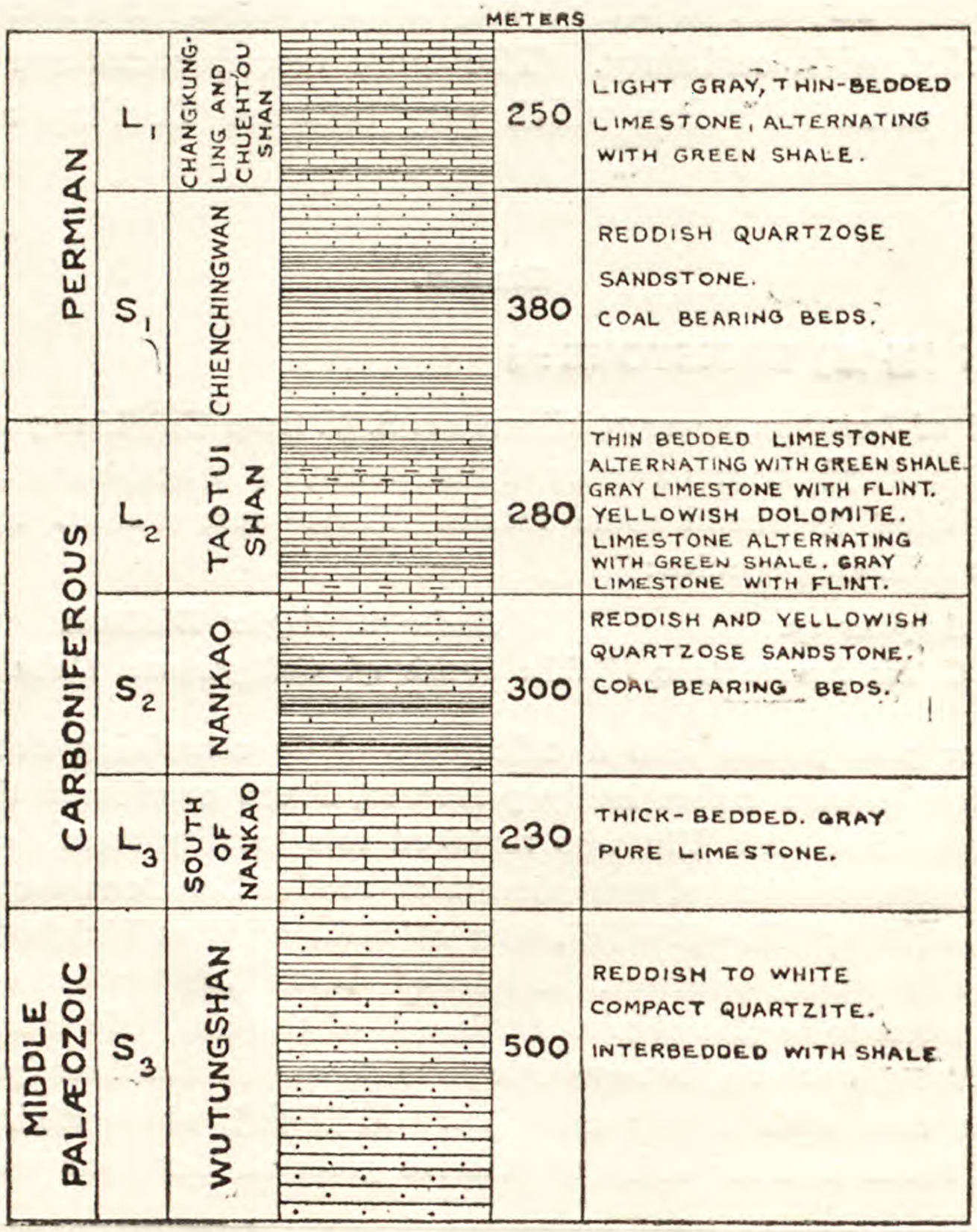


Fig. 1.—Generalized stratigraphical section, Ch'anghsing, Chekiang.
By V. K. Ting and L. F. Yih.

IN OTHER PLACES NEAR CHINKIANG:—

The limestone at Lunshan was the only Ordovician rock identified by Richthofen as such, but there is reason to suppose that the same horizon is to be found elsewhere. As already indicated, the limestone at Shanmienshan belongs to the same system (See Fig 3). This strikes E.N.E., appearing again on the S. slope of Ch'aohuangshan (朝皇山) (Tsauwangshan of Richthofen). It contains a thin seam of graphite which Richthofen seems to have believed to be altered coal seam, but its intercalation in limestone which dips under the quartzite speaks against his theory. Similarly, the limestone at Hsiangshan (香山) (See Fig 5) metamorphosed into marble by intrusive granite just S.W. of Kaotse may also be classified as Ordovician.

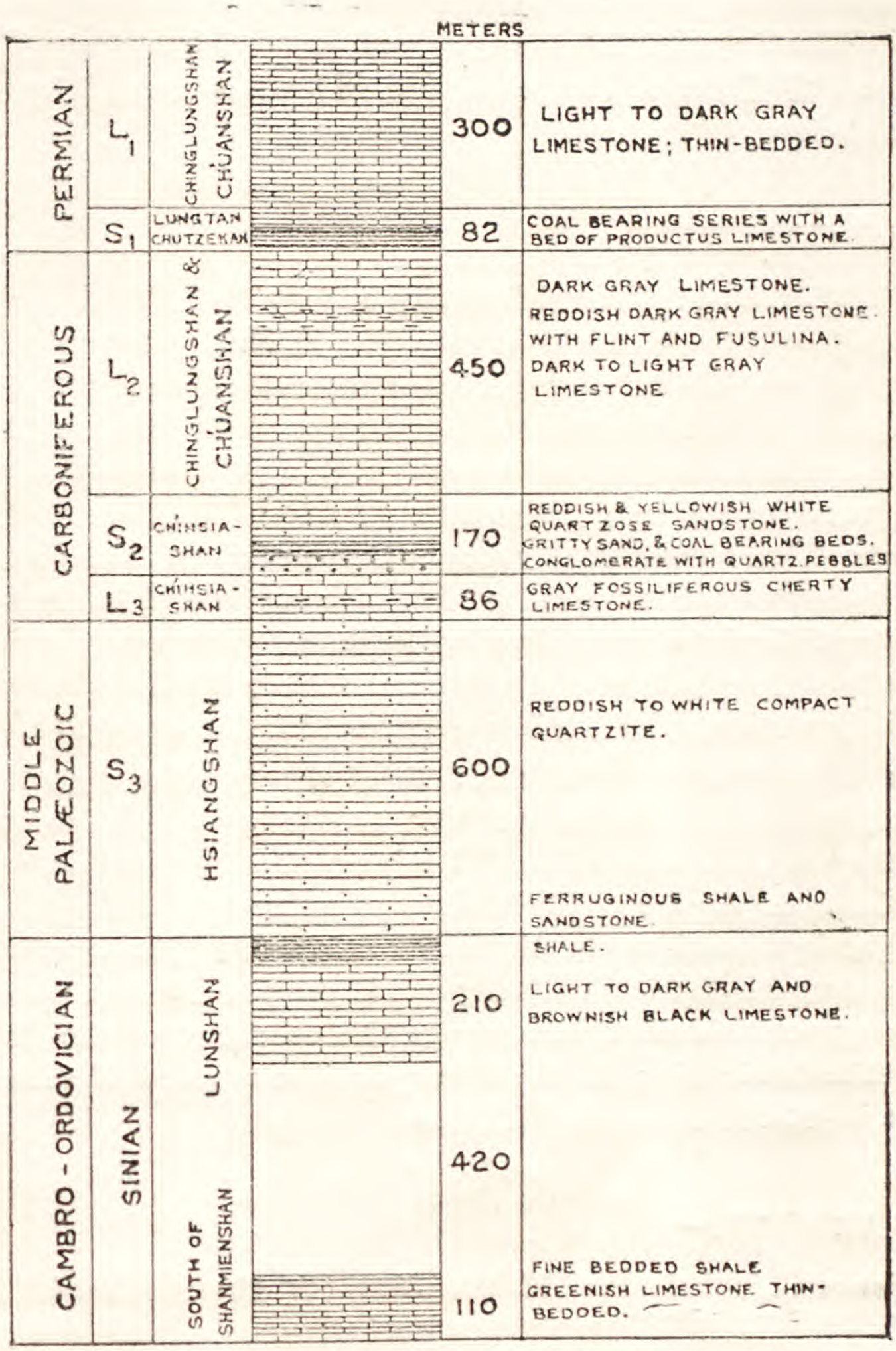


Fig. 2.—Generalized stratigraphical section, Nanking Hills. By L. F. Yih.



PLATE III.—Wut'ungshan, Ch'anghsing, formed by quartzite S3.



PLATE IV.—Yüancholing pass between Ihsing and Ch'anghsing, formed by quartzite S3.

Middle Palaeozoic (Devonian ?).

As already indicated above, the rocks that overlie the Sinian limestone are mainly quartzite and quartzose sandstone. The age is somewhat uncertain, but it is underlaid by the Lunshan limestone and overlaid by another limestone containing Lower Carboniferous fossils. It represents therefore the transition from Early Palaeozoic to Carboniferous time. It has a thickness of probably more than 600 metres and has a very wide horizontal extension; for, owing to its superior hardness, it forms the highest mountain ranges outside the axial chain. The boundaries between the three provinces Anhwei, Chekiang and Kiangsi consist entirely of this formation. It forms a semi-circular arc extending from S. E. of Chinghsien (涇縣) through the N. part of Ningkuohsien (寧國縣) to the E. of Kuangtêchow encircling thus the numerous small coalfields of S. Anhwei on its N. slope. The greater part of the hills between Nanking and Chinkiang as well as the island-like hills near Kiangyin (江陰), Ch'angshu (常熟) and T'ungchow (通州) are all formed by it. A few typical examples are given below.

IN THE NANKAO COALFIELD:

About 50 li W.N.W. of Ch'anghsing city and 30 li N.W. of the market town of Hoch'i (合溪) is situated the coalfield of Nankao (南皋). There are two series of coal forming a steep syncline. Underlying the lower measures is a thick series of quartzite interbedded with sandy shale and variegated sandstone. It is found on both limbs of the syncline—the northern limb rises up to 500 metres high and is known as the Wut'ungshan (五通山). The rock immediately above is a pure blue limestone with numerous small brachiopods, the age of which is probably Lower Carboniferous. The quartzite series is not fossiliferous, and owing to the luxuriant growth of bamboo and bushy vegetation on the softer beds, it is very difficult to give a detailed sequence. The whole series as exposed at Wut'ungshan is at least 500 M. thick. As this is certainly the best section I have seen, I propose to call this formation, Wut'ungshan quartzite (See Fig 9 and 10 and Plate 3).

The quartzite series that forms the S. limb of the syncline described above, strikes at first N. 30° E, but its prolongation to the S.W. gradually turns N. to strike nearly N.S., forming the boundary between Anhwei and Chekiang. On the eastern slope of this range is the coalfield of Kuangtê. In the south it turns to strike S. S. W. and becomes lower and lower until a low gap is formed to the N. W. of Ssüan (泗安). Further to the north it strikes E-W, separating the districts of Ihsing and Liyang in Kiangsu from that of Kuangtê in Anhwei. Throughout this continuous range the character of the formation remains constant, the quartzite dominating, but the lower part is composed of softer sandstone and shale. The whole is 500-600 metres in thickness.

IN SOUTHERN ANHWEI:—

In the district of Chinghsien and Hsüanch'êng (宣城=Ningkuofu) there is a number of small coalfields (See Fig 18). To the south of these there is a more or less continuous range of mountains formed by very hard and compact quartzite. It strikes on the whole NE-SW dipping 30°-40° N.W. In many places it seems to lie directly under the lower coal

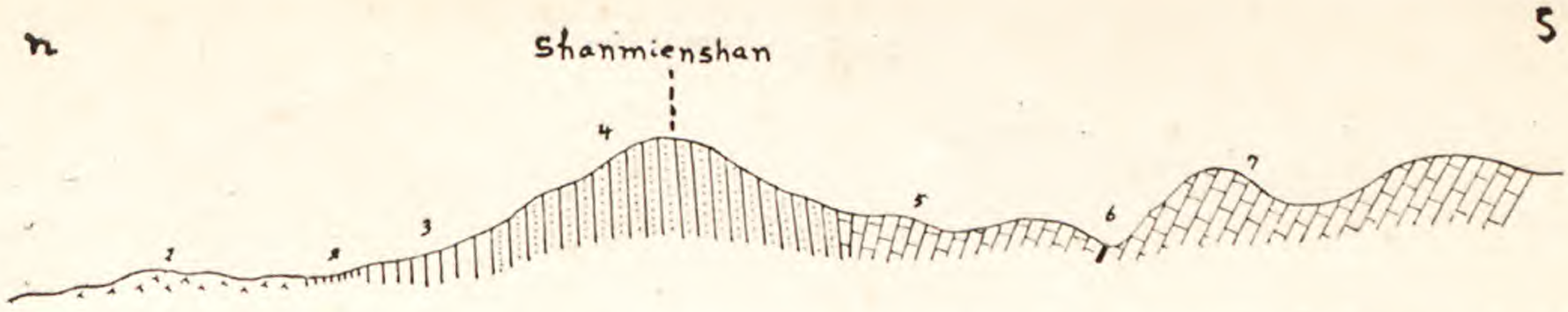


Fig. 3.—Section at Shanmienshan, Kaotse, Chinkiang. 1. Granite, 2. Loess, 3. Shale, 4. Quartzite, 5. Dark grey limestone, 6. Graphite, 7. Dark gray limestone.

Horizontal Scale 1 : 40,000
Vertical Scale 1 : 34,000
By L. F. YIH.

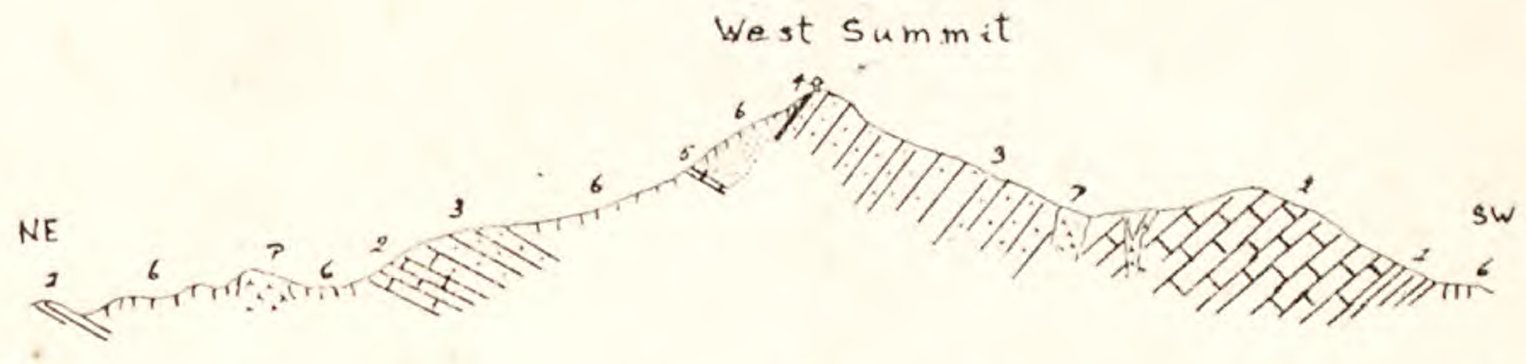


Fig. 4.—Huashan—2. Yellow and violet shale. 2. Yellowish black semi-crystalline limestone and marble with porphyry. 3. White and compact quartzite. 4. Red and green micaceous shale. 5. Gray limestone. P. Porphyry. 6. Covered part.

Horizontal Scale 1 : 30,000
Vertical Scale 1 : 25,000
By L. F. YIH.

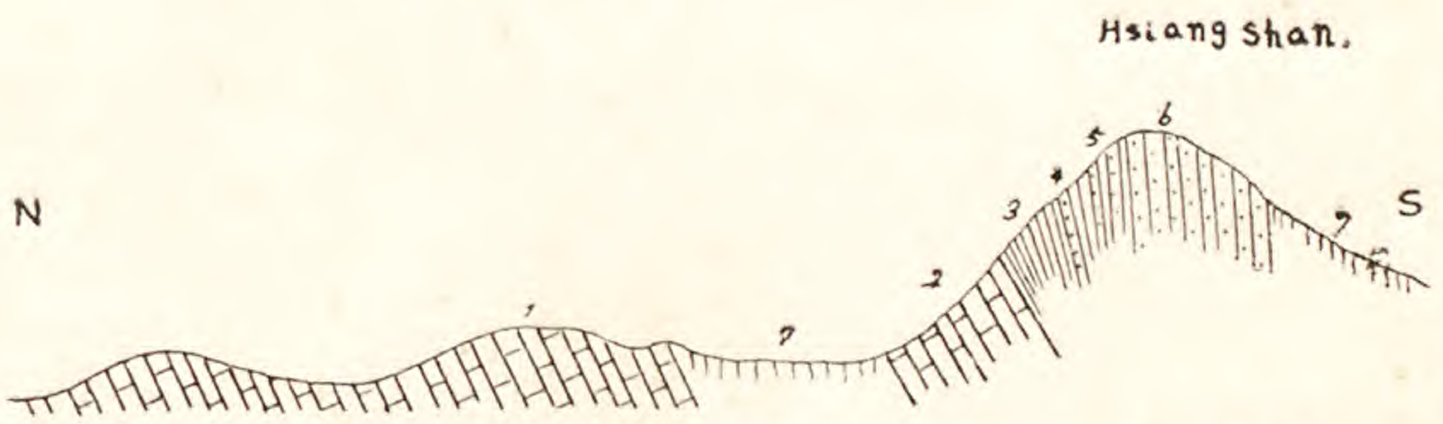


Fig. 5.—Section at Hsiangshan, Kaotse, Chinkiang.—1. Black banded marble, dissected by prophyry. 2. White marble. 3. Ferruginous and calcareous, black shale, intruded by porphyry. 4 White quartzite. 5. Greenish, grayish soft micaceous sandy shale. 6. White compact quartzite.

Horizontal Scale 1 : 6,000
Vertical Scale 1 : 20,000
By L. F. YIH.

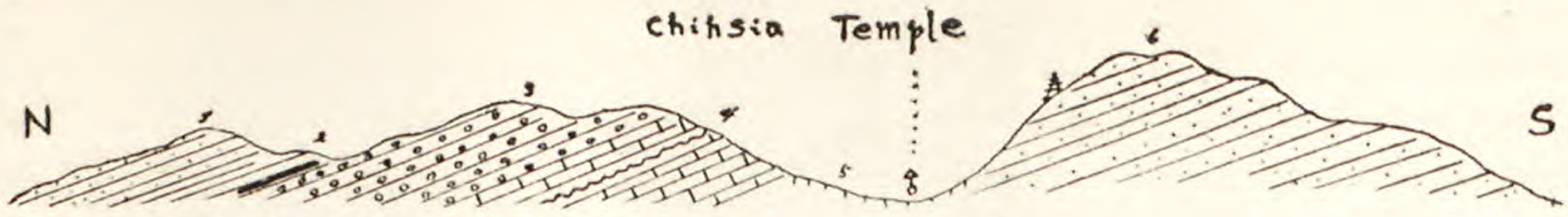


Fig. 6.—Ch'ihsiashan.—1. Quartzose sandstone.2. Coal bearing beds. 3. Conglomerate. 4. Dark gray cherty limestone, where fossils have been found. 5. Covered by alluvium. 6. Quartzite.

Horizontal Scale 1 : 10,000

Vertical Scale 1 : 5,000

By L. F. YIH.



Fig. 7.—Section at T'ungkuanshan, Ihsing. L_3 = light limestone with bands of white marble; S_3 = compact quartzite with softer yellowish sandstone.

Horizontal Scale 1 : 50,000

Vertical Scale 1 : 20,000



Fig. 8.—Section at Nant'ouling, Ningkuo. L_1 = thin-bedded gray limestone alternating with shale; S_1 = soft yellowish sandstone with coal seams; L_2 = similar to L_1; S_2 = soft sandstone with coal seams; S_3 = white compact quartzite.

Horizontal Scale 1 : 50,000

Vertical Scale 1 : 20,000

series. This is well seen in a section at the pass of Nant'ouling (南頭嶺) 20 li from the town of Shuitung (水東) 60 li S. of Hsüanch'êng where 2 series of coal measures occur, each overlaid by a limestone, and the lower series underlaid by the quartzite (See Fig 8).

IN THE DISTRICT OF IHSING:—

As already mentioned, the mountains separating the province of Kiangsu from that of Anhwei consist entirely of the same quartzite. In Liyang district the foot hills are formed by younger porphyry, but in Ihsing about 12 kilometres S.W. of Changchu (張渚), it strikes at first NE-SW, then N-S., enclosing on its western side the small coalfield of Lishan (犁山) (See Fig 16). N.E. of Changchu, the Lower Carboniferous limestone is extremely well developed, striking N.W., dipping at first N.E., then S.W., forming thus a gentle syncline. The northern limb of this is the conspicuous mountain of T'ungkuanshan (銅棺山) only a few li from the city of Ihsing. The summit is entirely formed by the hard quartzite, but the lower part consists of softer reddish sandy shale, and the part that is in immediate contact with the overlying limestone is a yellowish sandstone. The whole is at least 550 metres thick (See Fig 7).

IN THE NANKING HILLS:

The same quartzite occurs very extensively in the hills between Nanking and Chinkiang (the Nanking Geberge of Richthofen). It has been identified in the Huashan (Hwashan) § (華山), Wutsushan (Wutsoushan) (武祖山), Ch'angshan (Tshangshan) (長山), Ch'aohuangshan (Tsauwangshan), Lunshan, Ch'ihsiashan (Hsishiashan) (棲霞山) and the ridge between the village of Mêngt'ang (孟塘) and T'angshui (湯水). §§

The occurrence at Lunshan and Ch'ihsiashan deserves special mention. In the former it overlies directly the Lunshan limestone (Ordovician) in contact with the graptolitic shale, whilst in the latter it underlies the Lower Carboniferous limestone. According to Richthofen §1 the series consists of brown quartz sandstone, and softer variegated shale and sandstone. The section has been restudied by Mr. Yih in a place N.W. from Richthofen's locality (See Fig. 6) and he found that to the S. of the Ch'ihsia temple, where the pagoda stands, the predominant rock is a hard brown quartzite (equivalent to Richthofen's conglomerate and sandstone), which is identical with that of Wut'ungshan and elsewhere. In this way the age of this formation is limited between Ordovician and Lower Carboniferous. In nearly all the hills mentioned the quartzite strikes ENE—WSW.

Carboniferous and Permian.

The Carboniferous system is here of extreme complexity. Many of the horizons are still imperfectly known, and owing to the similarity of petrographical character, and comparative poverty of type-fossils, the different series are by no means easy to distinguish. The best and most complete section known so far is that of the coalfield of Nankao in Ch'anghsing district, Chekiang. I will here describe it first in detail and then try to correlate it with the other localities.

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§. Those in brackets are Richthofen's spelling.

§§. See "China" III p. 757 Table V.

§1. China III p. 707.

IN THE NANKAO COALFIELD: (Fig 9 & 10.)

As already mentioned, the coalfield of Nankao is situated 50 li W.N.W. of the city of Ch'anghsing. The whole formation forms a syncline with its axis running N.E.—S.W. The N.E. end is closed, i.e., the beds gradually turn round to form a closed basin, but at the S.W. end they turn to strike N.W—S.E. and the extensions further N. have not been followed. Beginning with the southern end, we have

(1) Hard compact quartzite with interbedded shale and sandstone in the upper horizon (Devonian)—500 metres.

(2) Thick-bedded, fossiliferous, pure, blue limestone from which a collection of small brachiopods was made—230 metres.

(3) Lower coal series which has only a small outcrop, but from the development work done by the Changhsing Coal Mining Co., we have the following detailed section :—

(*a*)	Sandstone and shale	?
(*b*)	Sandstone	11
(*c*)	Shale	35
(*d*)	Sandstone	1
(*e*)	Shale	49
(*f*)	Coal seam	0.3
(*g*)	Bituminous shale	6
(*h*)	Coal seam	0.7
(*i*)	Shale	6
(*j*)	Coal seam	0.025
(*k*)	Gray greenish sandstone	35
(*l*)	Coal seam	3
(*m*)	Yellowish red soft sandstone	?
	Total	147 metres

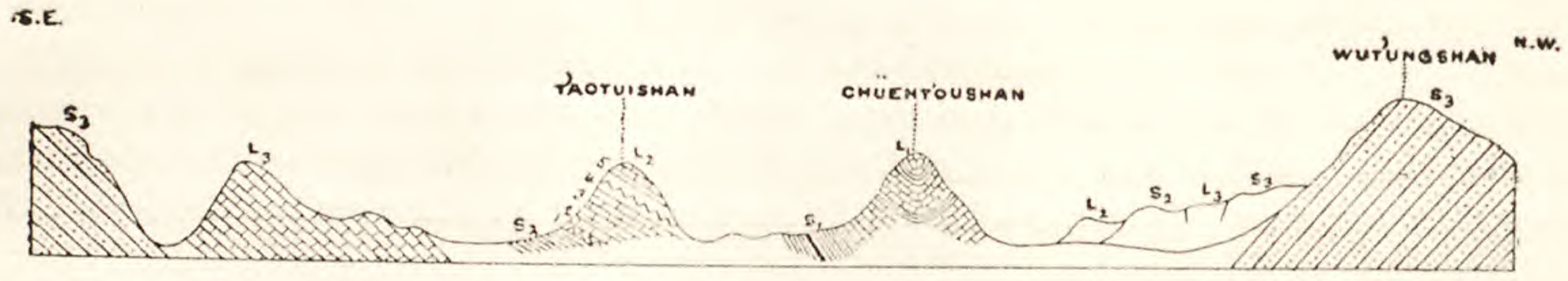


Fig. 9.—Section across Nankao Coalfield, Chekiang :—S_3 = reddish white compact quartzite interbedded with variegated shale; L_3 = thick-bedded pure grey limestone; S_2 = coal bearing series; L_2 = 1. thinbedded cherty limestone; 2. light gray limestone alternating with green shale, 3. yellow thick-bedded dolomite, 4. cherty limestone, 5. light gray limestone alternating with green shale, S_1 = coal bearing series; L_2 = light gray, thinbedded limestone alternating with green shale. By V. K. TING and L. F. YIH.

Horizontal Scale 1 : 100,000

Vertical Scale 1 : 400,000

Judging from the distance between the underlying limestone and the overlying formation, this series must have a thickness of 300 M.

(4) Limestone interbedded with shale. From bottom upwards:—

(*a*) Light gray limestone with patches of flint, bedding 2—3 feet thick.

(*b*) Thinbedded limestone alternating with soft greenish shale without flint.

(*c*) Yellowish dolomitic bands moderately thickbedded.

(*d*) Greenish limestone with patches of flint, bedding same as a.

(*e*) Thinbedded limestone alternating with soft greenish shale.

Total thickness... ... ... 280 Metres.

(5) Upper coal series, chiefly composed of easily weathered yellowish red quartz sandstone. There is said to be three seams—the uppermost (?) seam is about 2 M. thick being worked by the Kuanghsing Coal Mining Co. (**廣興公司**). Thickness 380 M.

(6) Upper limestone, thinbedded, alternating with soft green shale much as in (4), but without any chert. Thickness 250 M.

(6) forms the axis of the syncline, hence, as we go further north, we have 5—1 repeated—the quartzite of Wut'ungshan forming the lowest limit.



Fig. 9.—Map of Nank'ao Coalfield, Ch'anghsing.

Besides the small brachiopods in 2, plant fossils occur in the dump heap of the Ch'anghsing Co's mine. The exact horizon is not known, but probably from (2). Besides some ferns, we have the following genera :—

Annularia *Calamites*
Sigillaria *Pecopteris*
Lepidodendron

all of which are of course typical Palaeozoic forms. In (4) only a single brachiopod had been found, but in thin sections there are fragments of Fusulina, so there is little doubt that it corresponds to the well-known Fusulina limestone of Asian continent.

In order to facilitate description I have named the above 6 formations by the letters S_3, L_3, S_2, L_2, S_1, & L_1 as shown in Fig. 1 and 10.

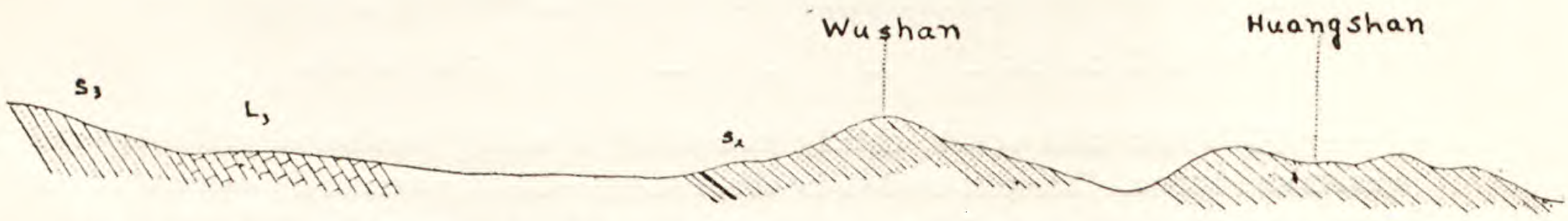


Fig. 11.—Section at Wushan, Changhsing :—S_3 = brown compact quartzite; L_3 = blue limestone; S_2 = quartzose sandstone with coal bearing beds.

Scale 1 : 50,000

The Fossiliferous formations of Ch'ihsiashan (棲霞山) and Ch'uanshan (船山) (Tsushan of Richthofen).

As the fossils collected in my journey have not yet been determined, we must try to correlate the formations with those already known in order to settle their age. Only two such horizons exist, both of which were first discovered by Richthofen. One is that of Ch'ihsiashan§, where above the quartzite and shales is a dark gray thinbedded limestone with chert nodules and silificied fossils. From this collection Fresh §1. distinguished the following species :—

Hallia gigantea Mich. sp.
Lonsdaleia floriformis Flem. sp.
? Lonsdaleia papillata Fisch sp.
Zaphrentis spinulosa M. Edw. et H. sp.
Battersbyia nov. sp.
Syringopora ramulosa Gf.
Fistulipora minor M' Coy.

All of which indicate Lower Carboniferous age. As described in the Devonian section, Mr. Yih found it to be underlaid by the typical quartzite, so it ought to correspond to L_3 in the Nankao section.

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§. China III p. 727.
§1. China V. p. 61.

The other place is the section at Ch'uanshan from which collection Fresh §2. identified the following species:—

Euomphalus pusellus Waag.
Productus scabriculus Mart. mut nov. nankingensis.
„ *sino-indicus n. sp.*
„ *lineatus Waag.*
„ *gratiosus Waag.*
„ *kiangsiensis Kays., (=tumidus Waag).*
Derbya sp.
Chonetes strophomenoides Waag.
Streptorhynchus pectiniformis (Davids.) Waag.
Dalmanella marmorea Waag. sp.
Athyris capillata Waag.
Locyella nankingensis Frech.
Polyzoa aff. Ornatae Waagen.
Fenestella cf. perelegans Meek.
Lonsdaleia salinaria Waagen.

The formation is considered by Fresh to be Middle Permian with the reservation that *Productus scabriculus* may indicate a lower horizon. These fossils occur in the lowest horizon in the coal series which is 120 M. thick, underlaid by a series of limestone, 450 M. thick, containing abundant chert at certain levels. This limestone contains also Fusulina. The rock that overlies that coal series is also a limestone. A comparison with the section at Nankao shows clearly that the three upper horizons L_2, S_1, and L_1 are here represented.

From the above consideration we may classify them as follows:—

L_3 Lower Carboniferous.
$\left.\begin{matrix} S_2 \\ L_2 \end{matrix}\right\}$ Middle and Upper Carboniferous.
S_1 Permian.
L_1 Permian or Triassic.

SOME DIFFERENT FACIES:

The sequence outlined above is the most complete one we have seen in the Lower Yangtse, but there are at least two horizons which seem to have different facies in different localities.

The most certain one is that of S_2. In the Nankao section detailed above, it consists of shales and sandstones more or less soft in character. But this is by no means universal. In the small coalfield of Wushan (吳山), some 60 li S. of Ch'anghsing city and also in the

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§2. China V. p. 165—7.

Ch'anghsing district, a series of hard, rather coarse quartzose sandstone, striking N.W.—S.E. dipping 40° N.E. forms the two isolated hills of Wushan and Hungshan (紅山), the former of which is 300 metres high (See Fig II). At the S. foot of Wushan (thus at the base of the sandstone series) there are some old shafts, mining coal. This is limited by a N.W.—S.E. directed valley, on the southern side of which are quartzite hills 300—400 metres high. On their northern slope is a small outcrop of a pure blue limestone used locally for burning lime. Both the quartzite and the limestone have the same strike and dip as the upper standstone of Wushan. The natural interpretation is that here we have outcrops of S_3, L_3 a·d S_2, but in the last formation hard quartzose sandstone replaces soft sandstone and shale with probably a consequent thinning of coal seams.

More extensive study shews that this facies is very important. In two well-known localities, that of the Hsihu or West Lake (西湖) near Hangchow, and the region near T'aihu (太湖) and Soochow, it attains its maximum development.

In the West Lake it forms the well-known hills of Pekaofêng (北高峯) and Lungching (龍井) (whence comes the famous green tea), which encircle the lake from N.W. to S.W. At the S.W. end it is overlaid by a limestone more or less thinbedded, containing chert in many places and abundant in Fusulina, i.e., the L_2 horizon. Here the hard sandstone undoubtedly corresponds to S_2. (See Fig. 12).

In the Hsitungt'ing (西洞庭) island in the T'aihu, a series of hard quartzose sandstone, yellow to white in colour with interbedded soft bands, form the highest peaks of the island. (See Fig. 13). In the northern part it strikes N.E.—S.W. and dips N.W., but there is a sudden reversal of dip to the south. After a short interruption of alluvium, limestone with the same strike and dip appears as small isolated hills. It is pure enough for burning lime, but Richthofen § found some Foraminifera in it and stated that it contains chert patches, so it is undoubtedly L_2. Between the limestone and sandstone hill were situated the nine shafts sunk by the unfortunate Hsishan Coal Mining Company. The coal seams seem to have the same strike and dip as the limestone and sandstone to the N., but there is reason to suppose that the shafts were sunk at a fault. Nevertheless I consider the quartzose sandstone series to be below the limestone, corresponding thus to S_2, because of the general dip and the fact that sandstone of exactly the same character occurs in the Tungtungt'ing hill (東洞庭) (coloured "Untercarbon" in Richthofen's atlas sheet 52, as well as in the region N. of the T'aihu lake where some missionaries at Soochow found a good collection of fossils in the yellow shaly beds of the Inkstone Hill or Yen wa shan (硯瓦山) three miles W. of the village of Mutu (木瀆). The hill is isolated, but as it has the same strike and dip (N.W.—S.E., dip 30° N.E.) as the sandstone hills to the S.W.) there is no doubt that it is the upper part of the latter. A preliminary examination of these fossils have been made by the Smithsonian Institution and the following genera have been identified :—

Chonetes	*Aviculopecten*
Productus	*Solenopsis*
Leda	

§ China Vol. III 702.

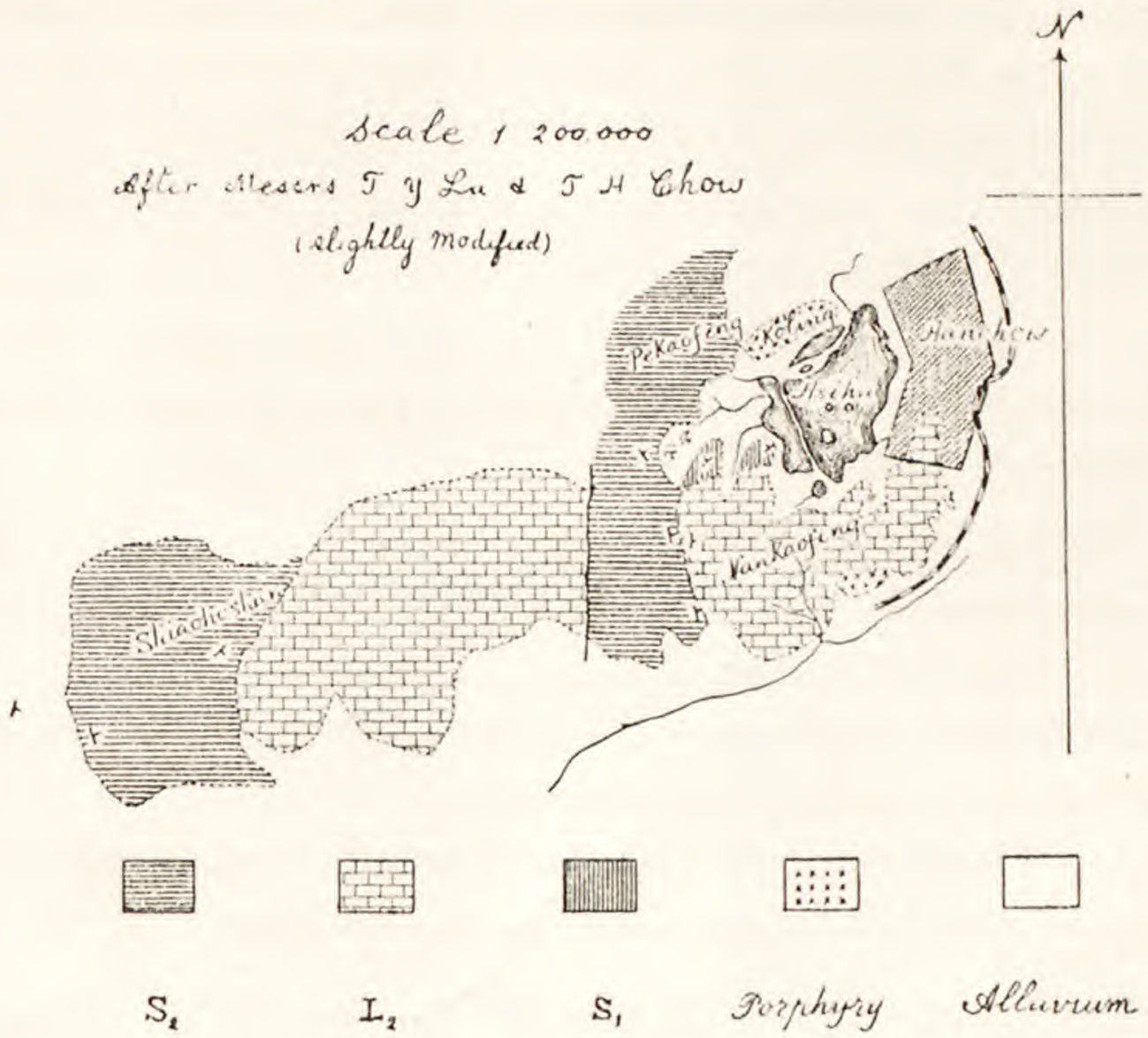


Fig. 12.—Geological map of Hsi Hu region.

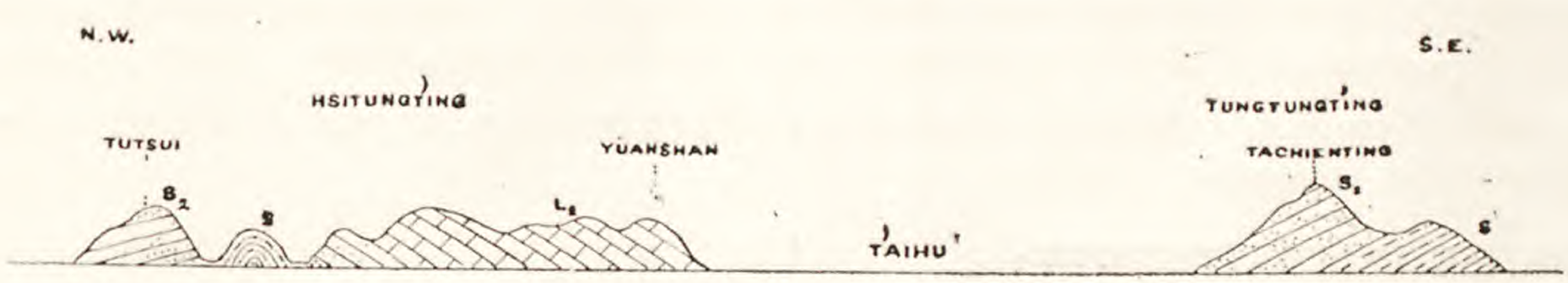


Fig. 13.—Section through the Hsi—and Tung-tungt'ing and the T'aihu. S_2 = yellowish quartzose sandstone; S = softer sandy shale; L_2 = Fusulina limestone.

Scale 1 : 100,000

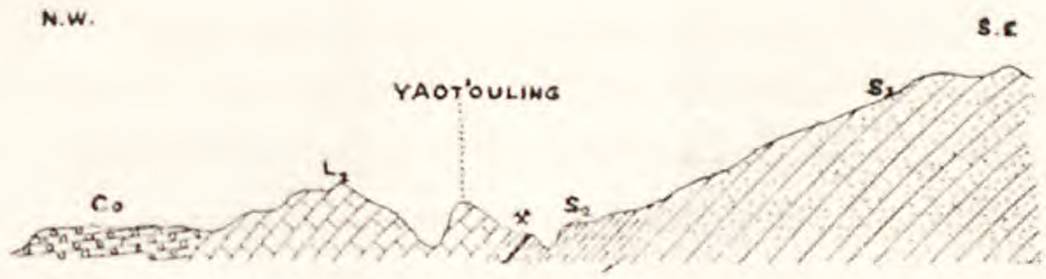


Fig. 14.—Section at Yaot'ouling, Chinghsien. Co = Conglomerate; L_2 = gray compact limestone; S_2 = coal bearing sandstone and shale; S_3 = quartzite.

Horizontal Scale 1 : 50,000
Vertical Scale 1 : 20,000

The palaeontologist considers these to be Pennsylvanian *i.e.*, Upper Carboniferous. I am much indebted to Mr. Brinkley of the Soochow University who not only communicated the facts but also sent some specimens to the Geological Survey.

It is to be noted that this quartzose sandstone is the original Tungt'ing Grit of Kingsmill, who insisted that it was Devonian.

The section at Ch'ihsiashan deserves also special mention. The limestone which contains Lower Carboniferous fossils is overlaid by the coal series which consists, from below upwards, of the following:—

(1) Ferrugenous yellow shale.

(2) Conglomerate with quartzite pebbles (=Richthofen's Chungshan (鍾山) Conglomerates).

(3) Black sandy shale interbedded with semi-anthracite seams.

(4) White coarse quartzose sandstone.

The occurrence of workable coalseams together with hard quartzose sandstone makes the series something intermediate between the two facies of S_2.

Another difference of facies is the case of L_1, though here the correlation is much less certain. As it has been described, L_1 occurs above a coal series the upper part of which contains marine fossils of Permian age. In the coalfields of Chiuli § (九里) in Anhwei, and Lop'ing §§ (樂平) in Kiangsi similar fossils occur, but only thin seams of limestone are found above—instead, we have a silicified limestone containing palaeozoic fossils. The thickness of this horizon is small (30 M. in Kiangsi §[1]). If we identify this with L_1, then L_1 is still Permian, or, if we regard it as a horizon to be included in S_2, then L_1 is probably Triassic.

PROBABLE UNCONFORMITY:

So far we have treated the different formations as continuous and concordant. As a matter of fact there is at least *one* probable unconformity. This is at the base of S_2. Two sections only shall be given here—both from southern Anhwei. About 9 li S.E. of the town of Shuitung in the district of Hsuanchang (Ningkuofu) two series of coal occur together (See Fig 8). The beds strike N.E.—S.W. dipping 30° N.W. The first series occurs between two limestones. The second series is below the second limestone, and is underlaid by a thick series of quartzite. Applying our nomenclature, we have L_1, S_1, L_2, S_2, and S_3, but L_3 is missing, so that S_2 rests directly on S_3. Similar conditions exist on the Yaotouling (搖頭嶺) and Chêhsingshan (柘形山) coalfields S.E. of Chinghsien, but there is only one series of coal lying presumably between L_2 and S_3. (Fig 14).

From the above consideration I think it is fairly clear that at end of the Lower Carboniferous there was a breach in the deposition of sediments, though it is not proved that there is any unconformity of dip between S_2 and L_3 or S_3.

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§. China Vol. V. p. 190.

§§. China V. p. 103.

§1. "Report on the Coalfields of Kiangsi" by Dr. W. H. Wong (not yet published).

THE COALFIELDS:

In addition to what has been mentioned the Permo-Carboniferous system occurs in widely scattered places. In most cases the tectonic conditions are complicated, so often the exact correlation is somewhat uncertain. I have only space here to give a very short account of some of the more important coalfields.

The coalfield of Kuangtê is situated some 50 li N.E. of the district city. There are two series of coal; the lowest one as seen at Hsiao Niutoushan (小牛頭山) rests directly on the quartzite (S_3) and overlaid by a fossiliferous limestone. The latter strikes NNE —SSW dipping 45° W.N.W. and is succeeded by a series of sandstone and limestone (S_2 and L_2) which is overlaid by another coal series, forming the base of Whangchiashan (王家山). The summit of the last named hill is formed by the limestone L_1 which is the axis of a syncline. On the W. limb, the limestone L_2 meets another strike fault, and changes its dip abruptly to the W. (See Fig 15).

The coalfield of Lishan, situated 25 li S.S.E. from the market town of Taipu (戚步) and 70 li S.S.E. from the city of Liyang, is a closed basin, consisting of the lower coal series S_2 and the middle limestone L_2 which forms the hill of Lishan. The lowest limestone L_3 is seen on the N. E. and N. W. side of the field but disappear in the south, probably due to faulting (See Fig 16).

The well-known temple of Maoshan in the district of Chüyüng (句容) is situated on a summit 250 metres high, formed by the quartzite S_3. Both to the N. W. and S. E. it is conformably overlaid by the limestone (L_3) Further to the S. E. between the Fangshan (方山) hill (S_2) and the Shihhuiyao (石灰窯) village, there is a series of yellowish sandstone and shale apparently overlying the limestone, but I had no time to study its exact sequence. It is provisionally correlated with S_2 (See Fig 17).

The southern Anhwei coalfields may be divided into 2 parts, the one to the W. and N. of Chinghsien city, the other, S. of Ningkuofu and E. of Chinghsien (See Fig 18). In the western field only the lower series S_2 occurs, lying apparently directly on the quartzite S_3, and overlaid by L_2. The tectonic conditions are complicated and it is cut up into several irregular fields. In the E. field, on the other hand the upper coal series S_1 dominates and is overlaid by a silicified limestone (L_1?) and underlaid by L_2. The horizon S_2 probably occurs in most places but is only worked in the S. W. part. The formations strike fairly regularly N. E.—S. W. and dip 30—40° N. W., but erosion has separated them into 4 disconnected fields, namely, the Shuihsiang (水巷) field 22 li N. of the market town of Shuitung, Chiuli field 70 li S. W. of Ningkuofu where Richthofen found the Permian fossils §., the Kuloupu (古鼓鋪) field 30 li N. E. of Chinghsien, and the Yaotouling field further West.

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§. China Vol. III p. 695

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FIG. 18.—Route Sketch through the S. Anhwei Coalfields.

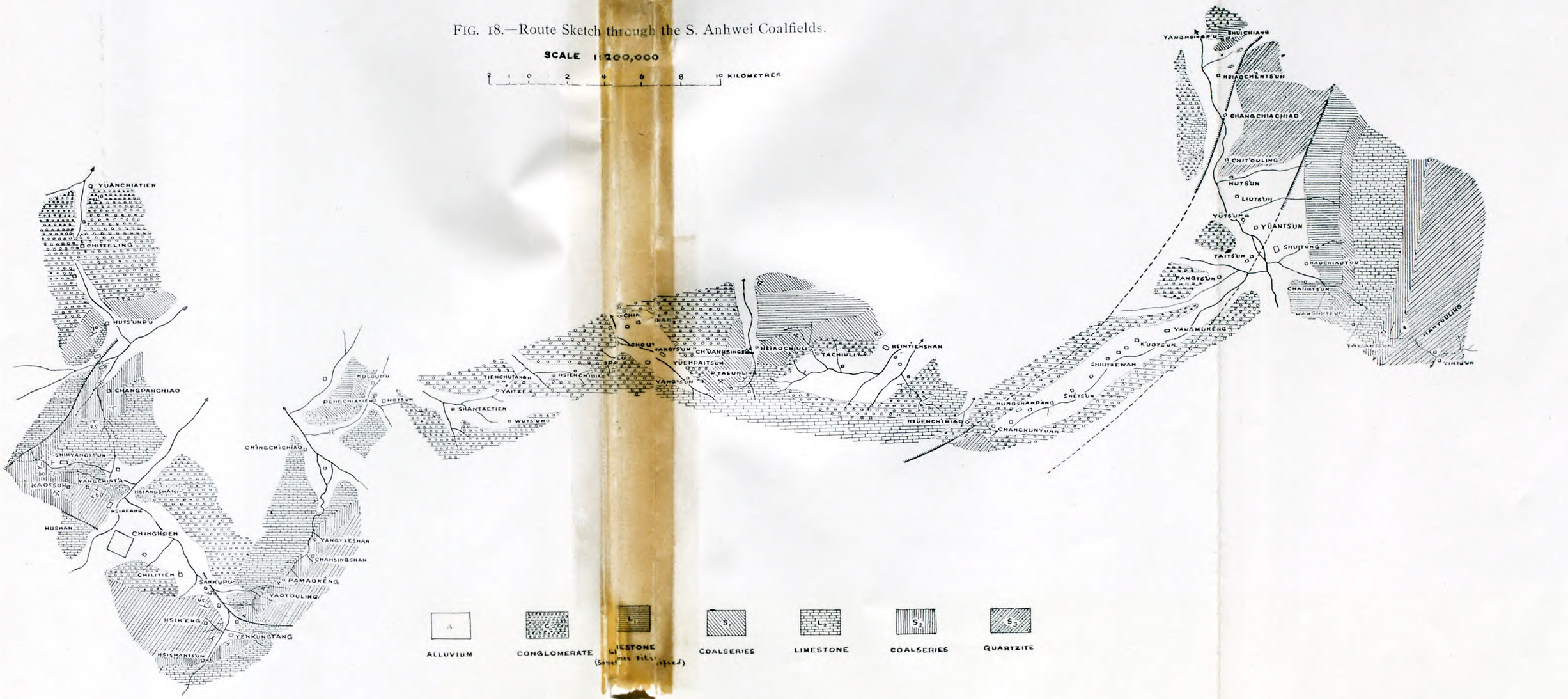




Fig. 15.—Section through Kuangtê Coalfield. L_1 = Thin-bedded limestone alternating with shale; S_1 = coal bearing soft sandstone; L_2 = gray limestone; S_2 = soft yellowish sandstone (coal bearing?); L_3 = pure blue limestone; S_3 = quartzite.

Scale 1 : 50,000

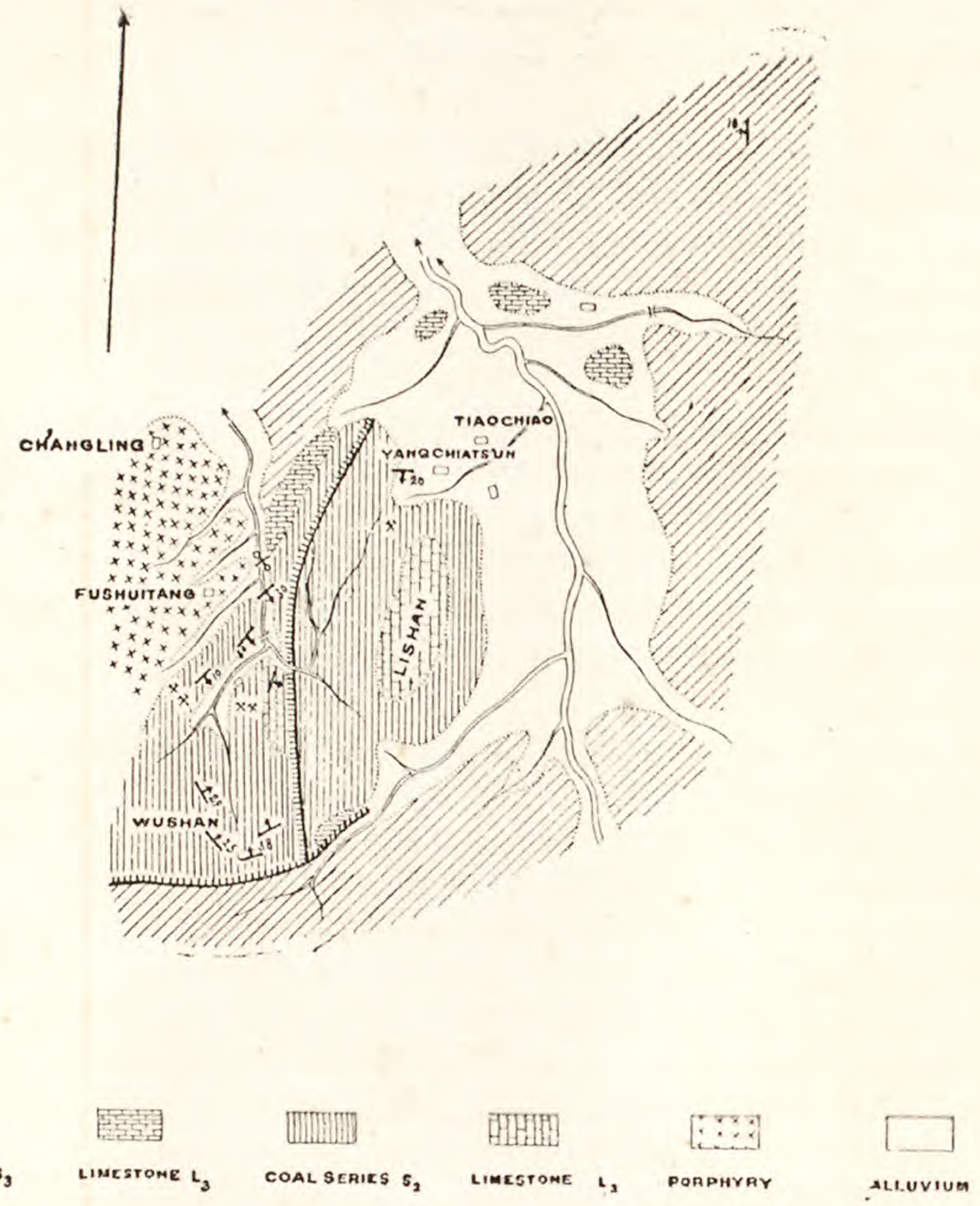


Fig. 16.—Sketch map of Lishan Coalfield, Liyang.

Scale 1: 100,000

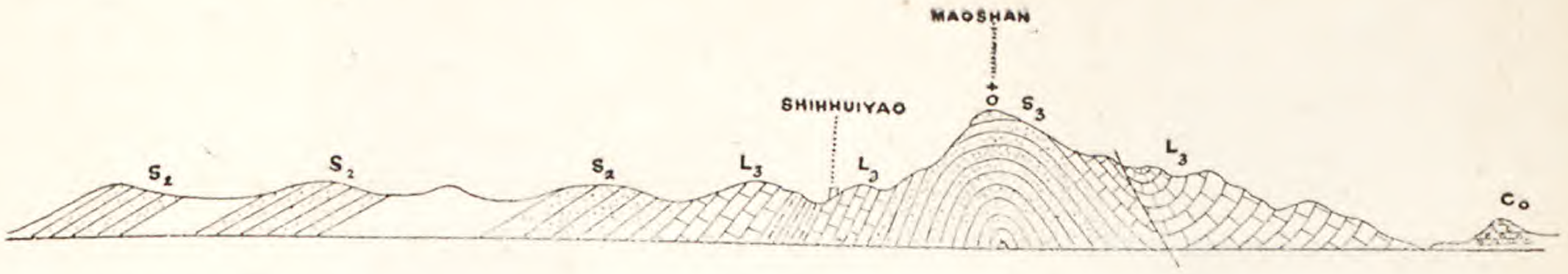


Fig. 17.—Section at Maoshan, Chüyüng. S_2 = sandstone; L_3 = pure blue limestone with occasional inter-bedded shaly sandstone; S_3 = quartzite; Co = conglomerate.

Horizontal Scale 1 : 50,000

Vertical Scale 1 : 20,000

DOUBTFUL CORRELATIONS.

So far the formations described certainly belong to the Carboniferous and Permian systems, but there are some other series which are more doubtful.

In crossing the mountain ranges from Shuitung to Kuangtê city, the quartzite S_3 is the predominant rock but towards the E. some 50 li S. W. from Kuangtê at the quarry of Shihhuiyao, a fossiliferous limestone of small thickness (60 M. +) is seen to overlie the quartzite (See Fig 19). It strikes here N.W.—S.E. dipping 30° N.E. Above it is a series of soft sandstone and shale mostly reddish in colour. At the contact it is quite conformable, but as we go eastward the valleys widen up and the series forms lower hills with gentler dip, giving the impression of being a rather recent formation. For lack of better evidence, it is coloured on the general map as S_2.

Another place is at the Foushan (浮山) 25 li E. from the city of Lishui. There a series of red sandstone and shale, comparatively soft in character, is overlaid unconformably by a basalt cap. The series as a whole strikes N.W.—S.E. and dips gently N.E. on the E. slope there are two abandoned coal shafts. It is questionable whether these ever reached coal, but provisionally it may be regarded as S_2 (See Fig 20).

Lastly, it must be mentioned that the part between Ningkuohsien in Anhwei and Yüch'ienhsien (於潛) in Chekiang regarded by Richthofen §. as "Sinian," may possibly belong also to the Carboniferous. No fossil was found by him, and the contact with quartzite S_3 at Ningkuohsien is obscured by a fault. Petrographically it is not different from L_1. The fact that the L_1 horizon in Fanch'anghsien (繁昌縣) in Anhwei was mistaken by Richthofen for Sinian, and that in the neighbouring districts of Hsiaofêng (孝豐) and Lingan (臨安) along the direction of the strike, coal is known to occur, speak with some force against his opinion. The writer has not visited this region, therefore it is coloured as Sinian with some reservation.

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§. China III p. 683—693.



Fig. 19.—Section at Shihhuiyao, Kuangtê. S_3 = quartzite; L_3 = pure blue limestone; S_2 = soft variegated sandstone.

Horizontal Scale 1 : 50,000
Vertical Scale 1 : 20,000

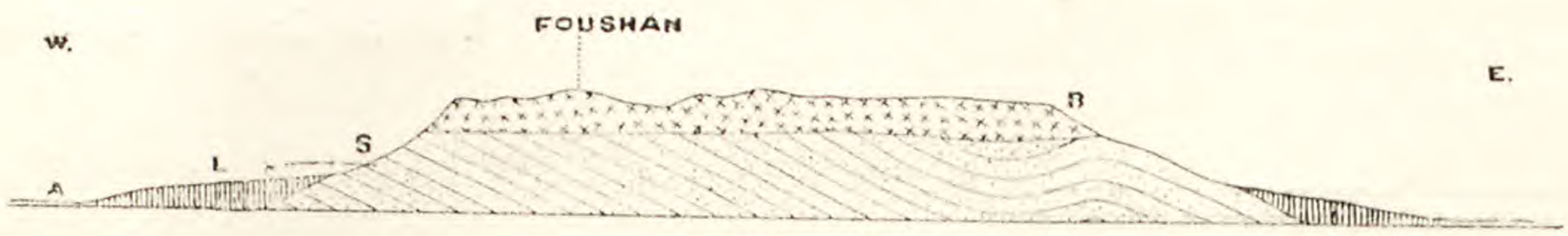


Fig. 20.—Section at Foushan, Lishui. A = alluvium; L = loess; S = reddish sandstone; B = basalt.

Horizontal Scale 1 : 40,000
Vertical Scale 1 : 20,000



Fig. 21.—Section near Huangmotu, Fanchang. S = coal series; L = gray limestone; Co = conglomerate.

Scale 1 : 25,000

NOMENCLATURE:

It is customary to give to each individual formation a geographical name which is often that of the locality in which it has been first discovered, but sometimes it is more convenient to name it after some place where the stratigraphical relation and palaeontological evidence are best known. Before going any further, therefore, I propose to give to the formations so far described the following nomenclature.

The Sinian system can have no better name than that of Lunshan where it was first seen by Richthofen. Only we must enlarge its sense a little so as to include the greenish limestone found by Mr. Yih to the north of Lunshan proper.

I have already used the name of Wut'ungshan for the quartzite S_3, for, though this horizon occurs in many places near Nanking and Chinkiang and was seen many times by Richthofen, its stratigraphical relation is not so well established there as in Wut'ungshan.

The Carboniferous and Permian systems are more difficult to name. Beginning with the horizon L_3, we find that Ch'ihsiashan has the best claim on account of its priority and stratigraphical certainty. The two facies of S_2 must be named differently: that which contains workable coal seams may be called the Nankao coal series, as we have plenty of plant fossils from there and there only; the quartzose sandstone series, which has usually no coal seams, has its best development in the east shore of T'aihu and the term Tungt'ing sandstone originally applied by Kingsmill may be retained with advantage. The limestone L_2 has always some Fusulina and it may be perhaps with justice called Fusulina limestone, but as it may not be the only Foraminifera limestone, I think the term Ch'uanshan limestone is better, as it was at that place, where Richthofen collected the Fusulina described subsequently by Schwager, and there it is overlaid by the coal series containing Permian fossils. The last named series occurs also at Lung'tan (龍潭) near Nanking, and is the only coal series in the Nanking Hills that is still being worked; it is therefore appropriate to use it for the S_1 horizon. So far no fossils have been found in the uppermost limestone L_1. I propose to give it the name Changkungling limestone which is a pass in the Chüeht'oushan (掘頭山) range in the Nankao coalfield.

To sum up we have:—

Lunshan limestone (S_1)	Sinian.
Wut'ungshan quartzite (S_3).....	Devonian.
Ch'ihsiashan limestone (L_3).....	Lower Carboniferous.
Nankao coal series (S_2) Tungt'ing sandstone (S_2) }	Middle Carboniferous.
Ch'uanshan limestone (L_2).....	Upper Carboniferous.
Lungtan coal series (S_1).....	Permian.
Changkungling limestone (L_1)	Permian or Triassic.

Tertiary.

The limestone L_1 is the highest horizon of older rocks exposed in the region in question. If L_1 is Upper Permian then all the mesozoic formations are absent. It is known, however, that mesozoic rocks do occur not far away, for in 1915, Messrs. Liu and Wang, both junior members of the Geological Survey discovered in a coalfield in the district of T'aihu (N. Anhwei) a coal series containing abundant plant fossils, which Dr. Halle of Stockholm thought to be undoubtedly of Rhetic age. Thus the absence of younger formations is rather the result of erosion.

THE TAT'UNG CONGLOMERATE:

The next series to be described is the wide spread conglomerate which Richthofen § called Tat'ung formation. In the region under consideration it occurs chiefly in S. Anhwei between the lake region and the mountains, extending right to the foot of the latter. In

§. China III p. 562, 694-696 and 750.



PLATE V.—Near Wuts'ung, Chinghsien. The Tatung conglomerate forms low hills in the fore-ground. The high mountains behind are formed by quartzite.

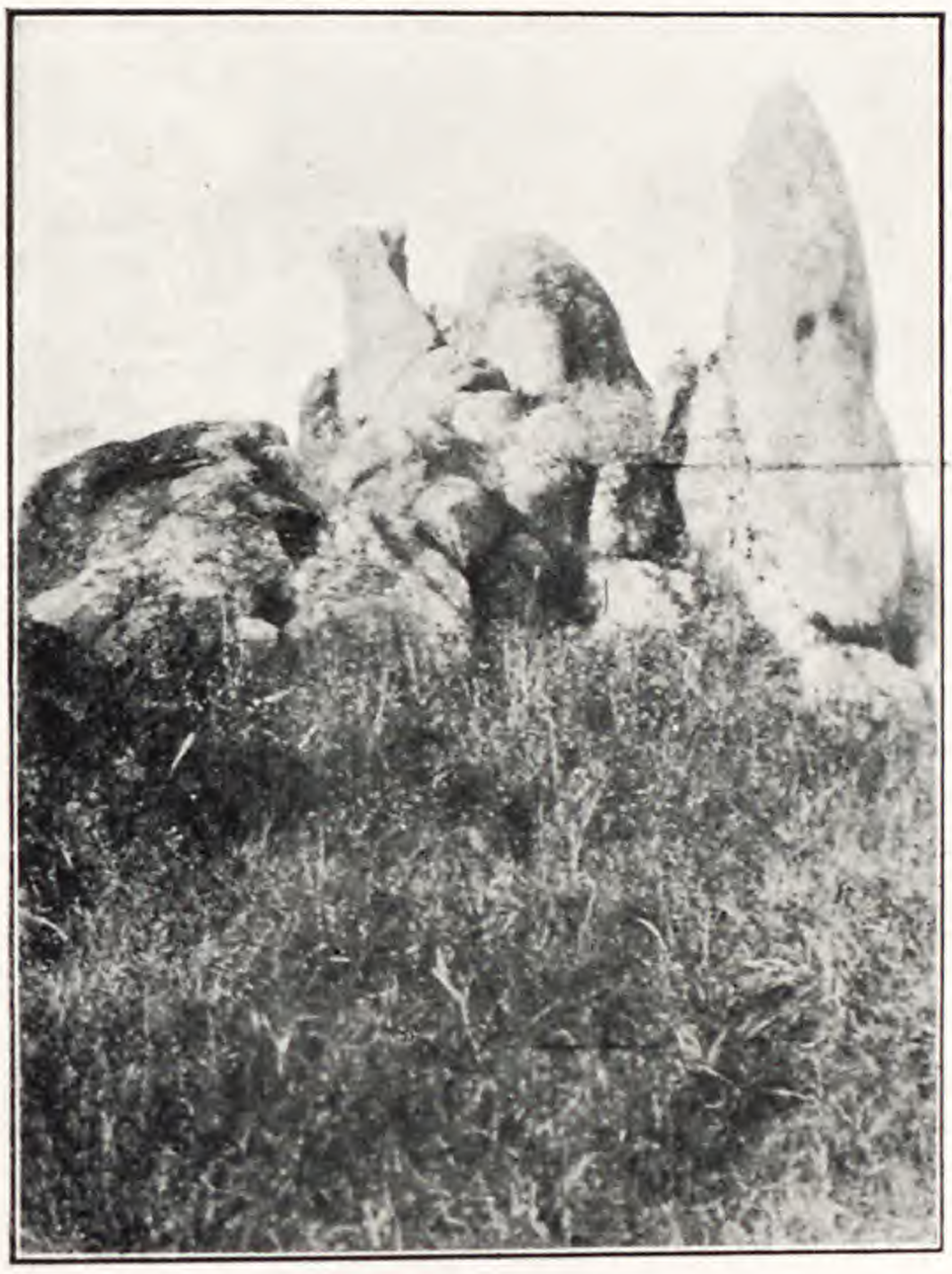


PLATE VI.—Summit of the granite hill of T'ienp'ingshan, Soochow, showing curious weathering form.

Kiangsu and Chekiang it occurs in isolated patches bordering the plane. It forms terraces 30—40 M. high, fairly well dissected by streams. In southern Anhwei the pebbles in the conglomerate are usually rather angular and often consist entirely of either limestone *or* quartzite changing within a short distance, but rarely the two are found together. It almost invariably dips with an angle of 6-7 degrees, usually away from the mountain (See Fig 21). Richthofen expressed rather contradictory views of its age §. When we come to consider the physiography and tectonic geology we will try to form a theory of its formation. Here it is sufficient to mention that I consider it to be late Tertiary in age.

Quaternary.

LOESS AND ALLUVIUM:

It is a remarkable fact that loess occurs extensively in southern Kiangsu and Anhwei and disappears further up the river. Here, as in its classical localities in N. China, it is a porous sandy loam with remarkable vertical cleavage. But it is seldom found on the top of hills except on the terraces formed by the Tat'ung conglomerate. Usually it forms terraces of its own in front of the higher mountains, but also covers extensive areas in certain parts of the planes. The age of loess is a difficult and disputed question. I have no space to discuss it here, but one thing is quite certain, that is, it is younger than the Tat'ung conglomerate. If we consider the latter as late Tertiary, then loess cannot be much older than early Quarternary.

The alluvium which covers the whole plane not occupied by the loess is without exception quite recent.

Igneous Rocks.

The igneous rocks of this region are of 4 types (1) granites, (2) intrusive porphyritic rocks, (3) rhyolitic and trachytic lavas, (4) basalts.

MODE OF OCCURRENCE:

1. Granite.

The true granites occur principally in 3 localities (1) in the hills S. W. of Chinking. (2) in the vicinity of T'aihu, (3) in the pass Ch'iench'iukuan (千秋關) on the border of Anhwei and Chekiang. Of the latter neither Mr. Yih nor myself have any personal observation, but it was well described by Richthofen §§. Of the first two localities a brief note must be made here.

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§. China III p. 751-752.

§§. China III p. 689.



PLATE VII.—Granite quarry of Chinshan, Soochow.



PLATE VIII.—Foushan, Lishui, showing horizontal sheets of basaltic lava.

The granite near Chinkiang §. is found on both sides of the Ch'aohuangshan range. The northern outcrop forms a continuous mass running nearly E-W. parallel to and in direct contact with the quartzite S_3. The northern outcrop consists of several small isolated hills. Both the quartzite and the underlying limestone have been greatly metamorphosed by the intrusion.

Near the T'aihu Lake granite occurs in 2 places: the one is the hill a few li S.W. of Huchow (湖州), the other is the group of hills W. of Soochow. At the former it is in contact with the quartzite S_3; but at the latter the main mass is the Lingyenshan (靈巖山)—T'iènp'ingshan (天平山) range, west of which is the Inkstone Hill, consisting of Upper Carboniferous sandstone S_2. The exact contact is opposite the famous quarry of Chiaoshan (焦山) 7 li N.W. of Mutu. Another quarry situated 7 li N.E. of Chiaoshan is the Chinshan (金山). These together supply large areas in the delta with building stone—most of the bridges on the Grand Canal owe their material to these two quarries. The well-known hills of Ssütseshan (獅子山) and Huch'iu (虎邱) are also formed by this granite.

Besides the above localities, an isolated outcrop occurs just below the pass Yofeiling (岳飛嶺) on the boundary between Kuangtê and Chienp'ing.

There is no means of determining the exact age of these intrusions except that they must be Post-Carboniferous.

2. Intrusive Porphyritic Rocks.

The typical quartz porphyry is mostly intrusive; it attains enormous development in the coastal region of Chekiang. Here it forms the well-known summer resort of Mokanshan. It is probable that it is continuous with the porphyry which Richthofen saw on his way from Yüch'ien to Ningkuo, for the famous T'ienmushan (天目山) range which occurs between these masses is known to be formed by porphyry. The other occurrences are near Nanking, chiefly as small dykes intruded into the various formations. The more basic variety occurs in close connection with the iron deposits of Chinlungshan (靜龍山) and Fênghuangshan (鳳凰山).

3. Rholites and Trachytes.

These acid lavas are confined to one belt extending from the S. of Liyang where they form the hills round the market town of Taipu, northwestward through the Lishui district to the S.W. of Nanking. The impression is that these lavas are comparatively young in age—probably Tertiary. An interesting example is the small outcrop of the "Rock of Thousand Men" at the celebrated hill of Huch'iu near Soochow. Here the tuff has a thickness of two feet forming a horizontal sheet on the granite.

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§. See also China III p. 713, 715 and Tafel V.

4. Basalts.

The volcanoes opposite Nanking on the northern side of the river were well described by Richthofen §. In every case the lava is basaltic. The writer first came across it on the summit of Foushan 25 li E. from Lishui city. There it is a flat sheet of pumaceous lava forming a cap upon the folded sandstone beneath. (See Fig. 20). Further to the east the N.-S. directed range of Fangshan, Yachishan (丫 髻 山) and Wawushan (瓦 屋 山) seems to be covered also by it. On the west slope of this range is a series of the Tat'ung conglomerate in which the pebbles are mainly limestone. No basalt pebbles are seen. It is therefore probable that the basalt represents the youngest eruption known in the Yangtsze Valley.

MICROSCOPIC DESCRIPTION.

My colleague, Dr. W. H. Wong, has kindly examined the thin sections of which here is a short description.

I.—Granitic Rocks.

1.—Granite near Yofeiling, Kuangtê District, Anhwei.

This is a medium to coarse grained granite. Under the microscope the rock shows a seriate intersertal texture, i.e., it is composed of large crystals of orthoclase the interstices of which are filled up by smaller crystals of quartz and orthoclase. Almost all the larger orthoclase crystals are twinned according to the Carlsbad law. Biotite is present in a rather subordinate amount, and often corroded.

2.—Granite of Chiaoshan, Soochow, Kiangsu.

There are two varieties of this rock; one is medium to coarse grained, whilst the other is fine grained. The coarser variety is more rich in quartz than the finer one. Crystals of orthoclase and quartz seem to have been formed in one and the same generation. This holds good also for the finer variety, which shows a fine seriate homeoid fabric under the microscope. Biotite is rather rare, and when present it is generally in small flakes or deeply corroded forms.

3.—Granite of Ssütseshan, Soochow, Kiangsu.

There seems no essential difference between this rock and the one above described. Orthoclase is a little more abundant: Size of crystals is sensibly more variable and irregular.

4.—Granite of Fuch'iu, Soochow, Kiangsu.

The section examined was cut from a weathered specimen. Almost all the orthoclase crystals are altered to a mixture of chlorite and chalcedony. Biotite has

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§. China III p. 733.

also completely lost its polychroism. Some masses of magnetite are present, probably. derived from the alteration of mica. Quartz is rare.

5.—Granite of Ch'aohuangshan near Nanking.

The constituent minerals are biotite, orthoclase, quartz and plagioclase. Quartz and orthoclase form sometimes graphic texture.

II. Intrusive Porphyritic Rocks.

1.—Quartz Porphyry of Mokanshan, Chekiang.

Sections made from different specimens collected from different parts of the hill are very similar. It consists essentially of phenocrysts of quartz, orthoclase and a microcrystalline groundmass composed of the same minerals. Quartz phenocrysts are generally much corroded. Plagioclase is very rare. Biotite is present as thin flakes in subordinate amount. The ground mass is always quite crystalline. The name of quartz porphyry given to this rock is not to be confounded with the rhyolite; this rock should be rather compared with what the French petrologists call "microgranite."

2.—Augite Andesite of Chinlungshan near Nanking, Kiangsu.

Almost all of the constituent minerals have been profoundly altered, but the texture is still well preserved. It is *dopatic* to *sempatic,* i.e., the phenocrysts are generally abundant and may be present in equal proportion to the groundmass. Crystals of felspar are all completely transformed by silicification and sericitisation. Augite is pseudomorphosed by iron oxide, leaving only the crystalline form still recognisable The groundmass is much obscured by alteration; probably its original composition consists also of felspar and some augite. Apatite is sometimes encountered as inclusions in phenocrysts.

3.—Biotite Andesite of Huashan, Nanking, Kiangsu.

This is also a depatic porphyritic rock. Biotite is the principal ferromagnesian element among the phenocrysts, the size of which varies from one millimeter to microscopic. Only a few crystals of hornblende are observed. The plagioclase phenocrysts belong to oligoclase. The matrix is a microscopically fine grained mass with chloritic substance due to alteration.

4.—Felsite of Mengt'ang, Nanking, Kiangsu.

This is a pale coloured rock with very little ferromagnesian minerals. The microgranular ground mass is mainly composed of small tabular crystals of orthoclase with a little quartz and scattered grains of magnetite. Phenocrysts of felspar are rather rare.

III. Volcanic Rocks.

1.—Rhyolite of Fuch'iu, Soochow, Kiangsu.

This is a porphyritic rock with small phenocrysts of orthoclase and a blackish brown groundmass. The thin sections show a most conspicious fluidal texture. The phenocrysts of orthoclase are generally very fresh and without twinning, most of them are orientàted in the same direction. A few crystals of hornblende are present. The ground mass is a brown glass with eutaxitic texture.

2.—Rhyolite of Mop'anshan (磨盤山) Liyang district, Kiangsu.

The phenocrysts consist of quartz and orthoclase: a few belong to oligoclase. The holohyaline groundmass shows a most distinct fluidal texture.

3.—Brecciated andesite of Ch'ihsiashan near Nanking, Kiangsu.

This rock consists of numerous fragments of an andesitic rock cemented together by a brown glassy mass. The fragments contain phenocrysts of plagioclase and altered hornblende scattered in a micro-crystalline groundmass. In some of the fragments the groundmass is microlitic. The glassy cement is not abundant. From the scarcity of the cement and the uniform character of the fragments it may be inferred that the andesitic rock, as soon as solidified, has met a volcanic explosion by which its fragments are broken and recemented by its own magna; it is not probable that the andesite is formed in a much older time than the volcanic activity to which is due the origin of this breccia.

4.—Tuff sandstone of Lunshan near Nanking, Kiangsu.

This rock contains irregular fragments of an andesitic rock closely similar to those observed in the volcanic breccia of Ch'ihsiashan. But the mass of the rock is a typical sandstone. The quartz grains are generally irregular and angular. A few felspar grains are also present.

5.—Brecciated Trachyte of Erhmaoshan (二茅山), Lishui district, Kiangsu.

This rock has a somewhat amygdaloidal texture with the vesicules filled up by an isotropic or extremely low birefringent zeolite. The rock itself consists of a microscopically fine grained mass of orthoclase, with a few phenocrysts of biotite. In some places the rock contains fragments of different textures, in which the orthoclase is generally crystallized into larger individuals, while the biotite may sometimes appear as needle-like thin flakes, almost opaque, owing to the segregation of the iron oxide. The groundmass surrounding these fragments shows sometimes a certain fluidality in the direction of the biotite crystals.

6.—Olivine Basalt of Foushan, Lishui District, Kiangsu.

This is a typical olivine basalt closely similar to that occurring over wide areas in Northern Shansi. Olivine is represented by a ferruginous variety, hyalosiderite. The groundmass consists of a doleritic mixture of labradorite and augite. But there are also some phenocrysts of a pale-coloured pyroxene which is probably diopside.

II. STRUCTURAL GEOLOGY.

A glance at the general map will show that the structure is one of extreme complexity. Again, the data upon which we must base our conclusions are gathered from various sources which vary very much in their degree of detail as well as their reliability. Added to this is the fact that greater part of the region consists of isolated groups of hills separated by wide stretches of alluvium under which the older formations are hidden. The following remarks are therefore nothing more than suggestions which may be found useful for future work.

General Considerations.

RELATION WITH NEIGHBOURING REGIONS:

Before we consider the structure of the region proper, a brief account of its relation with the neighbouring regions must be given. Two important facts stand out clearly. Firstly, the northern limit of the region under study lies directly on the S.E. edge of a mountain range of continental importance. The so-called Ch'inling or Tsingling (秦嶺) mountain which is the east extension of the K'uenlun (崑崙) system continues into the province of Honan through the Funiushan (伏牛山) range. After a narrow interruption the system is again recognisable in the subduced summits of the Huaiyangshan (淮陽山). At first the last named range has its leitlinien (or axes of folding) running N.W.—S.E., but when passing between the two districts of Huoshan (霍山) and Ch'ienshan (潛山) in N. Anhwei they gradually turn to strike N.E.—S.W. This part of the range has only an insignificant height, for it becomes lower and lower as we go further eastward. Its exact extension is not known, but the same system can be traced as far as the north of T'ungch'êng (桐城) and probably it is buried under the young volcanic rocks further east. The fact that the Ch'inling range is represented right to the border of Kiangsu, and that the direction of the leitlinien turns N.E.—S.W. is of great importance, for not only does this range divide the country into two different geological areas so that knowing the exact extension of the former helps to understand the difference in the latter, but also the area round the point of turning is the one subjected to the greatest pressure. The latter fact is well brought out by the earthquake records. It is known that the district of Huoshan has been a centre of earthquakes since a long time. After the earthquake of 24th January, 1917, the Geological Survey undertook to study its extent and distribution, and from some 200 reports an isoseismic map was drawn up and published. The same map is reproduced here. (Fig. 22). It shows clearly

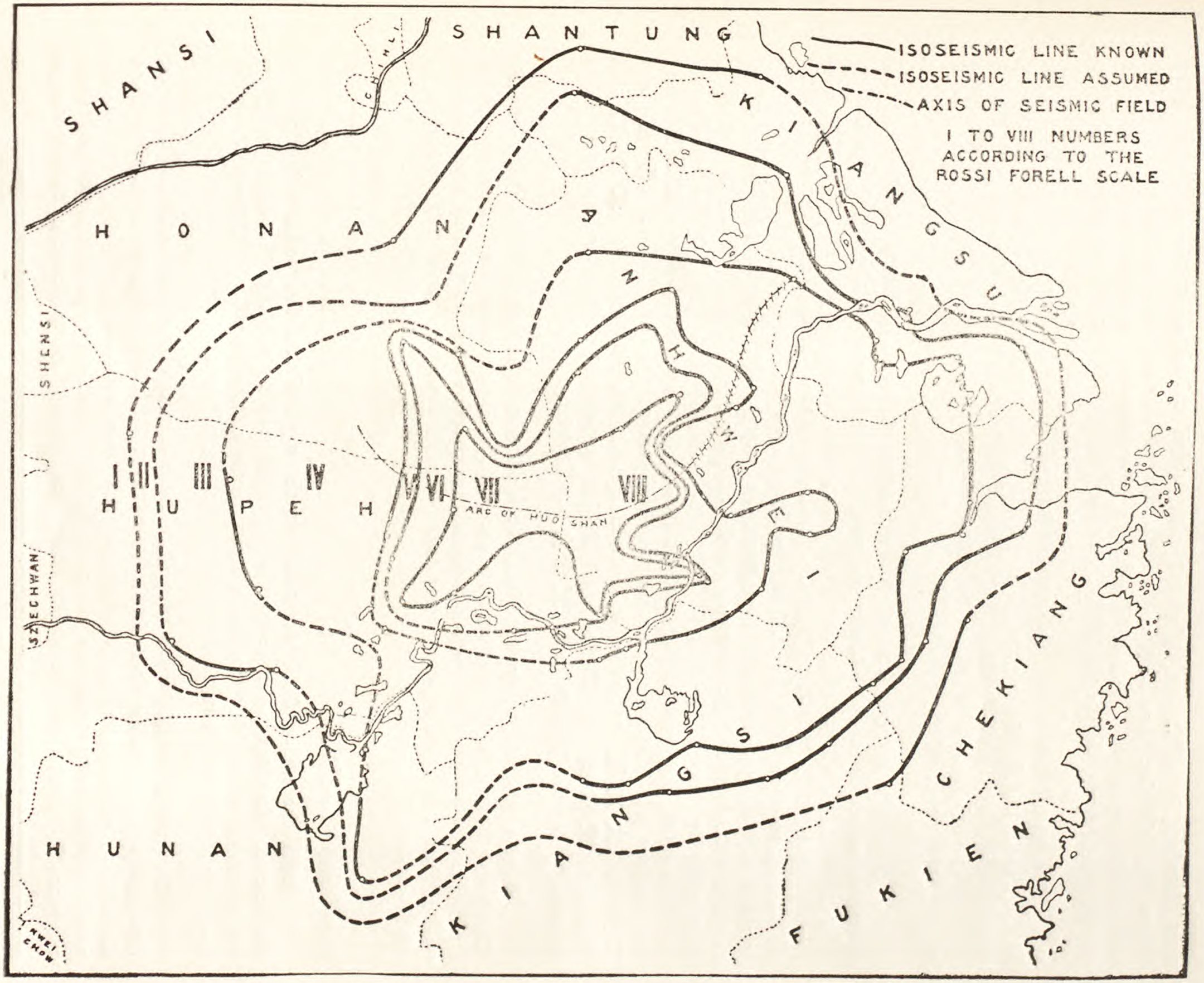


Fig. 22.—Isoseismic map for the Earthquake of January 24th, 1917.

that Huoshan is within an epicentral area which coincides exactly with the area where the leitlinien turn at 90°. For the sake of convenience I propose to call this part of the range the "Arc of Huoshan." It is important to remember here that the region under study lies to the S.E. of this arc. Its significance will be considered later.

The second fact is that the southern part of this region lies on the northern edge of the Nanshan (南山) system of Richthofen. He regarded the hills of Chekiang, Southern Anhwei, Fukien, Kwantung, Kiangsi and a portion of Kwangsi and Hunan as a geographical unit to which he gave the collective name of Nanshan. Speaking of the axial range of the Nanshan, he says §:—

"A minute investigation of the geological features of those portions of the Nanshan which have come under my observation shows that a general parallelism does prevail in all details, the trend being the same as that of the entire belt, namely from S.W. by W. to N.E. by E.—Long narrow belts, homogeneous in their geological structure and parallel to the trend can be detected. In those portions which I visited, and probably throughout its extent, the Nanshan is made up of these parallel belts." He then supposed that there was an axial chain following approximately the middle line of Nanshan, in a direction S.W. by W. to N.E. by E. This axial chain, according to him, passes between Shaochowfu (韶州府) and the border of Hunan and continues N.E.-wards to the Meiling (梅嶺) and Tayüling (大庾嶺) passes to be connected with the Wukungshan (武功山) and Wuishan (武彝山) of Kiangsi and Fukien respectively. Further northeast it is represented by the T'ient'aishan (天台山) of Chekiang.

Recent researches by the Japanese geologists and by the members of the Geological Survey, tend to show that the Nanshan has *several* parallel axes each of which forms a range of its own, with secondary complex structures, rather than a single well-defined axis as Richthofen supposed. It is however true that this system as a whole strikes N.E. by E., S.W., by W., and is formed by folded formations.

MAIN DIVISIONS:

From the above facts we would expect *a priori* that the north, being near to the Arc of Huoshan, is more profoundly influenced by folding, the south being on the periphyry of the Nanshan, has a most gentle undulation with a N.E.—S.W. strike. Such are indeed the broad features of the geological structure.

Examining the geological map, (See Plate I.) we will see at once that there are two regions in which the strike is almost constant. The one is the Nanking Geberge of Richthofen, consisting of parallel ranges with axes coinciding with those of folding which for the most part are directed E.—W. The other is the mountain system between Chinghsien and Kuangtê which are formed by moderately folded ranges

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§. Letters p. 63 et seq.

striking N.E.—S.W. For the convenience of description the latter may be called the Border Range, as they form, to the S.E., the boundary between Chekiang and Anhwei.

But a more detailed consideration will show that the structure is not quite so simple. First of all, the region W. of a line drawn from Wuhu to Chinghsien shows great complexity. The formations as a whole strike nearly E.—W., but with numerous turnings which complicate the structure locally, and from the E. of Fanch'ang in the direction of Wuhu abruptly change into a N.—S. strike. There is little doubt that here the limit between the mountains in the west and the plain in the east is caused by a fault, or a series of faults, so tectonically the region west of this forms an unit of its own (See Plate I.). Going from Chinghsien eastwards we have regularly striking areas but even before the city of Kuangtê is reached, the strike begins to alter into N.W.—S.E. The region between Kuangtê and the T'aihu Lake is again very complicated tectonically, but when the small basins with their local complications are excepted, the rocks on the whole strike N.W.—S.E. On the boundary between these two units we naturally expect the most marked disturbance, and it is a remarkable fact that a belt formed by more or less acid igneous rocks, partly extrusive and partly intrusive, runs from a point between Liyang and Kuangtê N.W.-wards, more or less continuously to the very banks of the Yangtse River, dividing the Shihch'u (石臼) and the Nanyi (南漪) Lakes from those of Ch'angtang (長蕩) and Ch'ihshan (赤山). Let us term this group as a whole Coastal Hills. The relation between these and the hills near Soochow and Wuhsi (無錫) is uncertain, but probably the latter represent the N.E. continuation of the axial range of granite and porphyry S.W. of Huchow. To sum up therefore we have five tectonic units namely (1) the Nanking System, (2) the Fanch'ang and Chinghsien Hills, (3) the Border Range, (4) the Coastal Hills, and (5) the Soochow Hills. Let us consider them in some detail.

Detailed Structure.

THE NANKING SYSTEM:

By the term I include not only the hills between Nanking and Chinkiang, but also the range on the northern bank of the Yangtse (the Nanking Gegengeberge of Richthofen) and the scattered hills east of Chinkiang not far from the Yangtse River. The first part is by far the best known. It consists of partially isolated parallel ranges formed by strongly folded formations. Owing to faulting and erosion, different elements have come together in an irregular manner. To simplify it a little, we may consider the whole system composed of three parts separated by faults. The west part is the simplest, consisting of two anticlines §. with their axis directed N.E.E.—S.W.W. The northern one coincides with the mountain of Wukungshan (五公山) by the very banks of the Yangtse river. On each side of this mountain the limestone dips away in opposite directions. The other anticline is just to the S. of the first, its axis passing N. of Chungshan which forms the southeastern limb. The Ch'ihsiashan anticline mentioned in connection with stratigraphy represents probably its north-eastern extension which has been somewhat shifted to the south by a fault. Further east it is cut short by a N.W.—S.E. fault of considerable magnitude and we come to the second element

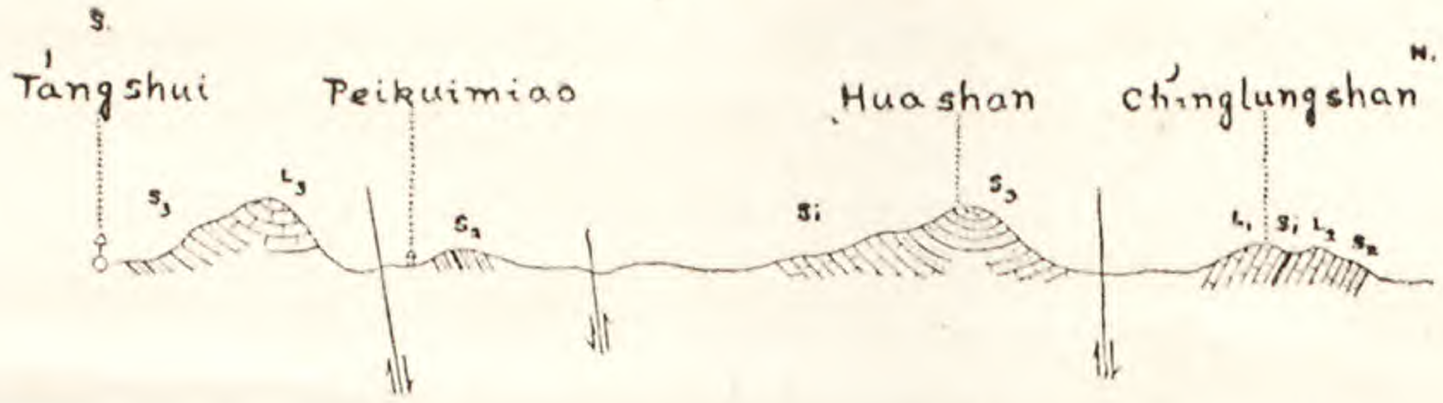


Fig. 23.—Generalized section through T'angshui, Peikuimiao and Ch'inglungshan.

Horizontal Scale 1 : 187,500

Vertical Scale 1 : 100,000

For nomenclature see general map (Fig. 25).

(See Fig 23). The latter is composed of the Huashan syncline in the middle, which is limited on both the north and the south side by a fault. On the northern side is the Ch'inglungshan (青龍山) range dipping south,—the fault between is probably a normal fault which has thrown the northern block some 500 metres down. The range between Mêngt'ang and T'angshui lies on the southern side and is separated from the Huashan proper by a wide strip of loess, but the Mant'oushan (饅頭山) in the east, and the Hushan (湖山) in the west, may be another syncline wedged in between two faults. Next we have the 3rd element, (see Fig 24) separated from the last one by a fault, which runs N.W.—S.E., and has thrown down the eastern part about 400 Metres. This group consists of a broken anticline, the axis of which must have been just to the south of Shanmienshan running eastwards to the south of Hsiangshan (香山) but now it is obscured by a thrust fault which has suppressed many of the formations on the northern limb, of which the Shanmienshan, Hsiangshan, and Ch'angshan etc. are remnants, whilst the southern limb is well represented by the Lunshan and Ch'uanshan. It is not certain how it is connected with the hills east of Chinkiang which have been studied, but the strike of the isolated hills between Kiangyin and Ch'angshu seems to indicate that this range has been bent to the S.E.



Fig. 24.—Generalized section through Lunshan and Shanmienshan.

Horizontal Scale 1 : 94,000

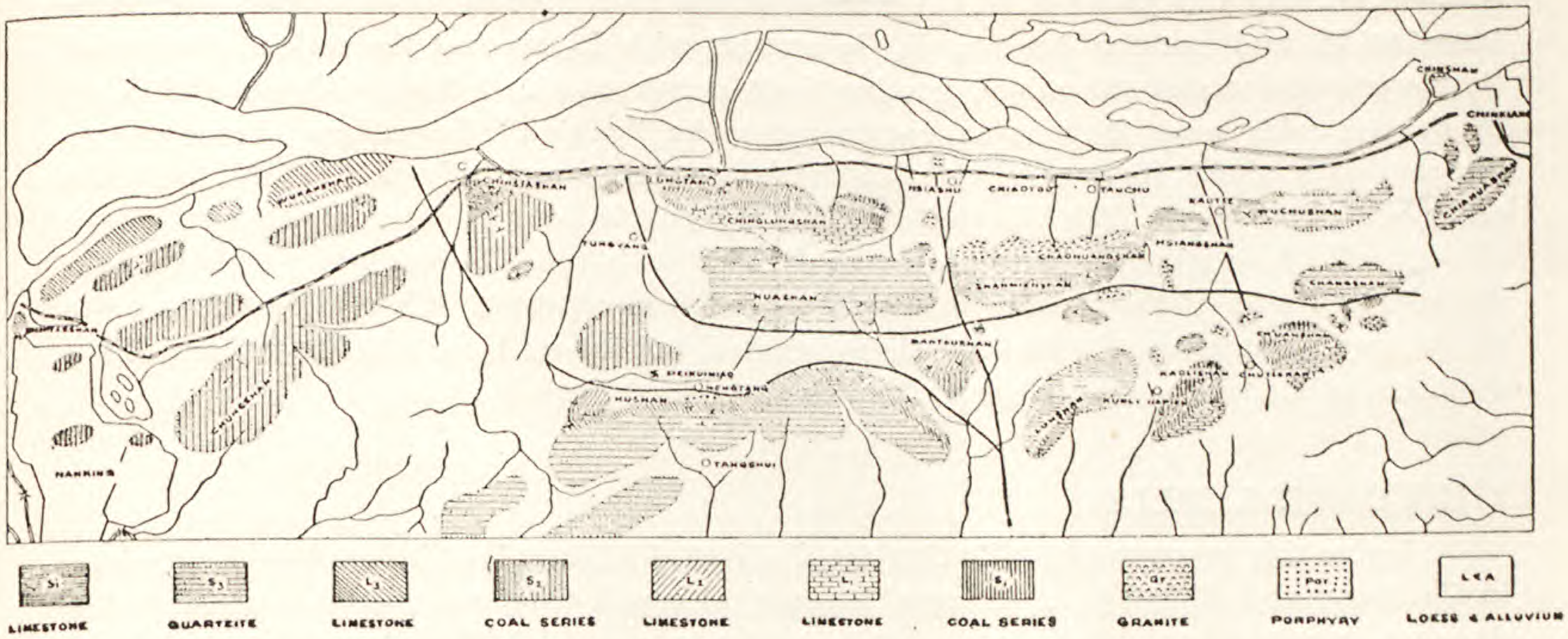
Vertical Scale 1 : 100,000

See Fig. 25. By. L. F. YIH.

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2. China Vol. III p. 730 Fig. 100.

FIG. 25 GEOLOGICAL MAP OF THE HILLS BETWEEN NANKING AND CHINKIANG SCALE 1:300,000 · BY L. F. YIN



It is interesting to notice that between the southern edge of the Arc of Huoshan and the Nanking system, occur the series of recent volcanoes described by Richthofen. §. The basaltic rocks formed from these seem to extend westwards to the low hills of N. Anhwei, cut through by the Tientsin-Pukow Railway. On the S. side of the Yangtse, the Nanking system meets a belt of igneous rocks to the west, and to the south it is obscured by loess and alluvium but it is probable that it is separated by faulting south of Chüyüng from the Maoshan and Foushan which belong to the Coastal Hills.

THE FANCH'ANG AND CHINGHSIEN HILLS:

Beginning with the isolated hills S. of Wuhu we have small limestone hills striking nearly N.—S. with a rather gentle dip, but clear signs of crushing and faulting. As we go further south folding becomes more conspicuous; a small outcrop of limestone near the village of Shihkui (石 脆) on the right bank of the river that connects Fanch'ang and Nanling (南 陵) with the Yangtse, 30 *li* from Wuhu, shows beautifully the effects of lateral pressure (See plate X.) Further south we are in the district of Fanch'ang and the strike of the formations turns 90° into E.—W. Numerous faults cut through the hills that surround the district city and the dioritic intrusions near the Yangtse river give rise to the well-known iron ores. The hills west of Nanling have not been investigated, but those west and south of Chinghsien have the same conditions, namely, the beds on the whole have a E.—W. strike, but it is complicated by the numerous local twists and turnings which make the line of strike go windingly. About 15 *li* south of the city we have the coalfield of Yenkungt'ang (晏 公 堂) where the coal series S_2 striking E.—W. meets a fault in its east part.

THE BORDER RANGE:

The Border range as a tectonic unit may be considered to begin east of the Yenkungt'ang fault. From here to the town of Shuitung the formations strike regularly

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N.E.—S.W. and dip 30-40° N.W. A normal strike fault throws the northern part down 500—600 M. and put the horizon S_3 in contact with L_1 so that the series is repeated. Southeast-ward across the range, another fault occurs south of Ningkuohsien and S_3 is in contact with what Richthofen considered to be "Sinian" formation. According to his section §. these form parallel folded ranges striking regularly N.E.—S.W., but with numerous strike faults. At the Ch'iench'iukuang pass a mass of intrusive granite breaks through which in the east seems to be continuous with the T'ienmushan porphyry. On the southern side of the granite the same condition is repeated. This in fact forms one of the important ranges in the Nanshan complex, but as we have already indicated, the direction of strike changes more or less abruptly further to the east.

THE COASTAL HILLS:

I give this name to the hills that are distributed along a line drawn from Hangchow in Chekiang and Chüyüng in Kiangsu, because, although they are now at a considerable distance from the sea, I believe that they were the true coast in quite recent geological time. On the whole their structure is most complicated, for here no axis of folding or lines of faulting goes along any distance; instead, we have a constantly changing strike causing the formation of small separate basins. Beginning with Hangchow, we have the synclinal basin of the West Lake (See Fig 12) which itself occupies the central part of a geological basin, the long axis of which is nearly E.—W., but to the west of the basin, the dominating strike is N.W.—S.E., and a normal fault makes the horizon L_2 and S_2 repeat themselves. The hills between Hangchow and Wuk'ang (武康) have not been visited, but west of the latter is the well-known Mokanshan formed by quartz porphyry. This porphyritic mass is continuous with the T'ienmoshan range. Soon however, the sedimentary rocks reappear and enclosed basins again form the principal feature. The semi-circular mountain ring beginning from Huchow and ending at Ch'anghsing is a N.E.—S.W. direct synclinal basin, broken up by erosion. The coalfields of Nankao and Kuangtê are both steep synclines (See Figs 9, 10 and 15); the former has a N.E.E.—S.W.W. axis, and is closed at the N.E. end, but the southwest part turns at right angle to strike N.W.—S.E. and is probably linked up with the N. end of the Kuangtê field which is formed by a syncline and an anticline both of which are cut by a fault. To the north of these two basins in the province of Kiangsu is the coalfield of Lishan (in Liyang district). It is a completely closed syncline broken longtudinally by a fault (See Fig 16). The hill range between the district city of Ihsing and the market town of Changchu is probably also a gentle syncline but its axis runs N.W. by W., S.E. by E. The range then is broken through by the river coming from Tungpa, but northwards the mountains reappear, the sedimentary rocks of which occur in the Foushan and the Maoshan ranges. The latter is a long and narrow ridge running at first N.—S. but further south it is joined with the Fangshan and Yachishan which begins to trend S.W.—N.E. ending in the Wawushan. The strike does not coincide with the topography, for at Yachishan it is in the direction N.E.—S.W., at Fangshan it changes into N.N.W.—S.S.E., at the southern part of Maoshan it is N.E.—S.W., but it becomes N.W.—S.E. on the northern slope. It is probable the west edge of this range is a fault. Thus, although

§. China III p. 683-696 Tafel IV.

no actual basin occurs here, the constant change of strike oscillating in the direction N.E.—S.W. and N.W.—S.E. shows that it is of the same nature as the hills of Ihsing and Huchow.

The occurrence of porphyry has already been noted. It is only necessary to mention that this belt is probably a zone of weakness along which great fracture has taken place. The exact line of fracture is not certain as it is now obscured by erosion and superficial deposition, but it is evident that the low land between the porphyry range and a line drawn through Wuhu and Chinghsien, partly now filted by recent alluvium, partly occupied by shallow lakes, is directly caused by these two lines of fracture.

Whether the east edge of these hills is a fault or what the Americans called warping, is not certain, but, as in most of the places the limit of the plane and the mountain is formed by abrupt escarpments, the former supposition is more reasonable. We may roughly trace it from Hangchow just E. of the West Lake northwards passing W. of Huchow along the west shore of the T'aihu Lake. After passing through Ihsing, it is shifted westwards so as to run N.W.—S.E., probably coinciding with the present boundary between loess and alluvium, but it may have occupied a more easterly position, since, as it will be seen later, general sinking of the coast has taken place If this representation is correct, then the Coastal Hills were originally a ridge with a big depression on the west and the sea on the east before erosion and sinking have together partly destroyed its continuity.

THE SOOCHOW HILLS:

In the delta small isolated hills are very numerous and scattered over a large area. Those between Ch'angshu and Kiangyin have been considered as the prolongation of the Nanking system on account of their concordance of strike. Those in the district of Sungkiang, (松江), for example, the Observatory Hills, and the hills north and east of Hangchow are all formed of porphyry. The structure of the Wuhsi hills is unknown. So it only remains to give a short description of the Soochow Hills. These hills may be divided into three groups: the granite group confined to the north; the East and West Tungt'ingshan (洞庭山), were both islands in the T'aihu Lake, but now the former is practically joined to the Mainland; and the Shangfangshan (上方山) and Ch'iunglungshan (穹窿山) group, which form the N.E. shore of the T'aihu. The Shangfangshan range strikes N.E.—S.W. and dips 40° N.W., but the Ch'iunglungshan group strikes N.W.—S.E. and dips N.E. The granite hills occur on the N. edge of this semicircle. Both of the Tungt'ingshan strike N.E.—S.W.: the West Tungt'ingshan is formed by an anticline, the S.E. limb of which is broken by a thrust fault ; the East Tungt'ingshan, formed entirely by S_2, dips N.W., in the opposite direction as the limestone L_2 that forms the S.E. limb of the West Tungt'ingshan anticline. It is very probable that a fault passes between these in the direction of strike through the village of Hsük'ou (胥口) northeast-wards to the granite hills. The relation of these hills with the other units is difficult to understand, as they are entirely separated.

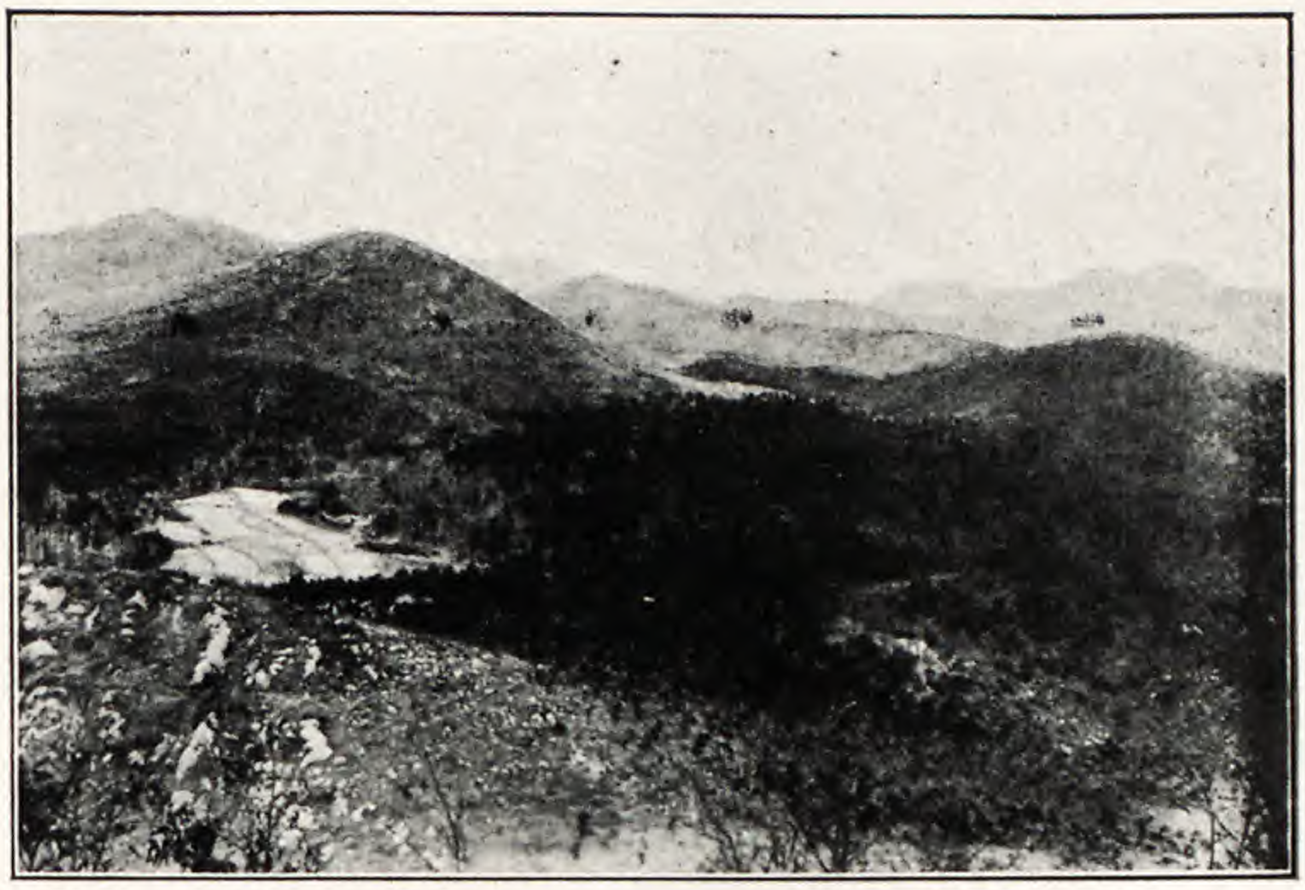


PLATE IX.—Coalfield of Kuangtê, taken from a hill at the S. end.

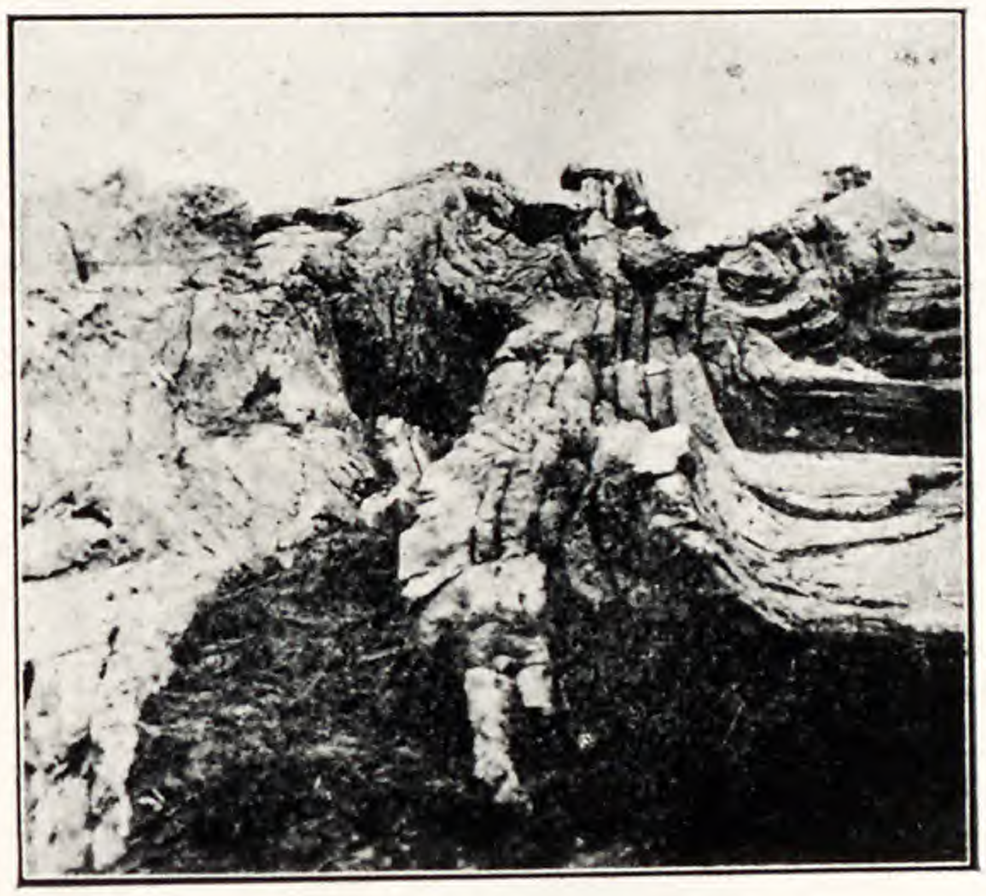


PLATE X.—A small outcrop of limestone near Shihkui, between Wuhu and Fanch'ang, showing folding and thrust.

Date of Earth-movements.

OCCURRENCE OF MIDDLE PALAEOZOIC :

When one considers the date of earth-movement in a given region, one must first consider if such movement has taken place more than once.

It is generally believed that the K'uenlun and the Ch'inling system were uplifted in Devonian time so that not only a distinct unconformity existed at that period, but throughout the region north of these ranges, no Devonian rock is known to occur; the Carboniferous rests directly upon the Sinian, i.e., the Cambro-Ordovician. As we regard the Huaiyangshan and the Arc of Huoshan as the eastern extension of the Ch'inling system, it is evident that the same truth must hold good. South of this range however the Wut'ungshan quartzite, occurring between the Ordovician and the Carboniferous, certainly represents the Middle Palaeozoic, and so far as we have observed, the sequences are quite continuous, though the amount of sediments deposited during that time is relatively small in comparison with those in the south-west provinces where the Devonian has a much more important development.

MIDDLE CARBONIFEROUS UNCONFORMITY :

Moreover in studying the stratigraphy we have seen that from the lowest formation, the Sinian, up to the uppermost limestone L_1, no *unconformity of dip* has been observed, but there is reason to suppose that an unconformity of erosion existed between the Upper Carboniferous and the Middle Palaeozoic so that the Lower Carboniferous is often wanting, being eroded away in some places before the horizon S_2 was deposited. This would necessitate the supposition that uplift took place immediately after the formation of the Lower Carboniferous, but no folding to any great extent occurred, as otherwise we must see some unconformity of dip between the Upper Carboniferous and the underlying rocks.

DATE OF FOLDING AND FAULTING :

Folding is however the striking feature of the present structure, and to some extent faulting also plays an important part. When then did these take place? Now, to answer such a question, it is necessary to consider what is the uppermost horizon that has been affected by folding and what

is the age of the rocks overlying unconformably above. In the region studied the uppermost folded horizon is the Permian limestone L_1, and the overlying rock is the Tertiary Tat'ung Conglomerate. So the folding must have taken place between the Permian and the Tertiary time. According to the evidence offered by the rocks in the neighbouring region, tectonically of the same unit, we can fix the date more closely, for in the district of T'aihu in Anhwei Province, folded Rhetic coal series are known to occur, so there can be no doubt that the date of folding is between Jurassic and Tertiary. There is reason to believe however that the Tat'ung conglomerate, the origin of which we will discuss in the next paragraph, was formed immediately after the folding. If we consider the conglomerate to be of Late Tertiary, then the folding cannot be earlier than Middle Tertiary. This conclusion will appear more certain when the physiography has been considered.

Origin of Tat'ung Conglomerate.

CONTRADICTORY VIEWS OF RICHTHOFEN:

Richthofen who first studied this formation thought that it was formed as it is, i.e., no deformation took place after its formation. This view he expressed most clearly in this "Letters," for there he says: §.

"The mode of origin of this formation is probably different from that of nearly all other sedimentary rocks. These are commonly supposed to have first been deposited horizontally, and to have been brought into their inclined positions by elevation. If such had been the case with the Tat'ung strata, they must have formerly consisted of horizontal deposits miles in thickness; and yet made up throughout of nearly nothing but conglomerates. The present position of the strata, dipping only at certain low angles, off from pre-existing declivities, and therefore in various directions, could only be explained by assuming a most singular and unheard of mode of action of elevatory forces. And how could it be explained, that these formations do only occur on the boundaries of the plain, and do not cover the hills, or portions of them? and how, that the terraces made up of them do not rise to an altitude exceeding about 120 feet? It is eminently probable, that the Tat'ung strata were originally deposited in their present position, and contain the record of a period of powerful denudation: that they were deposited at

§. "Letters" p. 101.



PLATE XI.—Below Nant'ouling pass, Ningkuo, showing the form of the valley cut in quartzite.

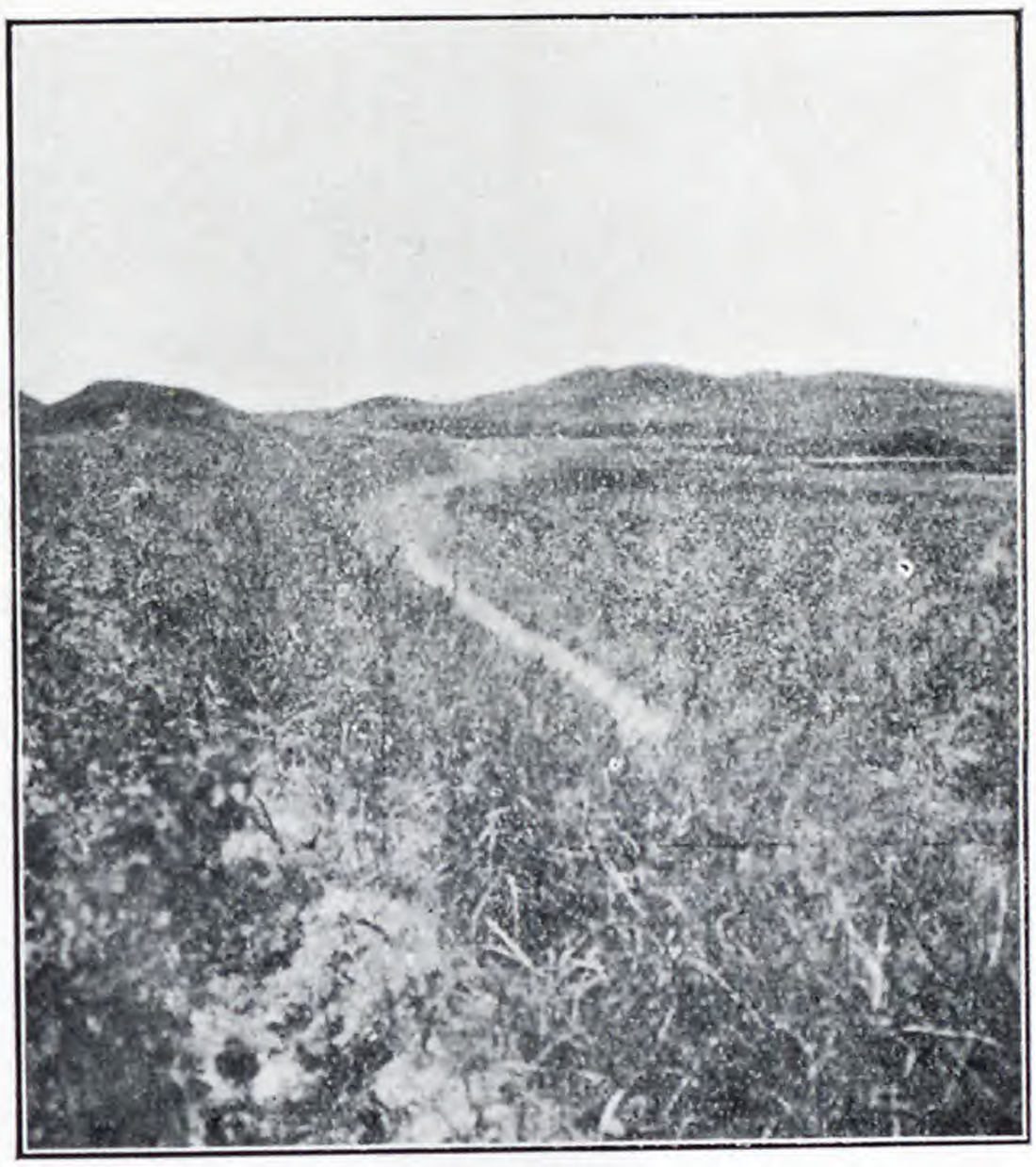


PLATE XII.—Loess terraces near K'unts'un, Lishui.

an epoch when the country had attained its general configuration, when the present mountain ranges were higher than they are now, and the present alluvial valleys were deep basins and depressions, bounded by steep slopes. If the sea filled these depressions, at a slightly higher level than it is now, the torrents descending from the surrounding mountains would carry down the rocky debris and, on reaching the sea, pour them down the steep slope, so as to form inclined layers."

But in the third volume of "China," published after his death, he changed his opinion entirely, and the Tat'ung conglomerate was supposed to have been uplifted and tilted, and the terrace form was attributed to subsequent erosion. Speaking of these terraces formed by the conglomerate he says on page 751: "Wherever I came upon it, it stood well out in inclined layers, which were cut off to a firm completely even surface. One is therefore inclined to seek an explanation of it as an uplifted and folded stratum."

CONCLUSION :

Of these two contradictory views I believe the former is the correct one, but it is not necessary to suppose that the sea actually reached these depressions. I need only quote from the same page as above to disprove the theory that they have been uplifted and folded, for he says further on:—"I have been over many miles width of the Tat'ung Terrace and never found an interruption, distinct change in the general trend, large variation of the dip, folding or perceptible alteration in the character of the stone. This formation only occurs at the foot of the hill, lands and never covers the hills or parts of them, and is never more than 120 feet above the plain."

Now all the characters described above are against the idea of folding. The occurrence at the edge of the mountain, the terrace form, the constant dip and strike, and, I may add the small dip angle which is never more than 10°, usually about 6°, rather indicate that the view expressed in the "Letters" is the correct one. Gravel beds resting on an incline slope often reproduce the angle of the slope in their bedding. Conglomerates very similar in character to the Tat'ung formation are well known in northern China, for example, the Wenho (汶河) Conglomerate of Southern Shantung which occurs near fault escarpments. When it rests on slightly inclined coal measures it appears to be tilted. B. Willis and E. Blackwelder, the two American geologists, who observed this formation in detail, regard it as ancient talus slopes and fix

its age as Tertiary. The same thing is found along the E. slope of the T'aihangshan (太行山) range, especially in Honan. Two things are necessary in forming such extensive conglomerates; the occurrence of a high and steep mountain edge bordering a plain, and a semi-arid climate. The former offers the best opportunity for forming an extensive talus, but with a wet climate, the gravel thus formed would be gradually washed away and has no chance to accumulate. Any one familiar with the scenery of Northern China must have been struck by the extensive gravel beds occurring between the plain and the mountain, for example in the Western Hills near Peking. Such gravel beds are absent in the South because climatic conditions do not allow it to accumulate.

We may suppose therefore that the folding and faulting which took place in Middle Tertiary time caused the formation of mountains much higher than they are to-day, and the extensive basin between the Yangtse and the mountain in S. Anhwei was already in existence. On the edge of this plain talus slopes were then formed. Change of climate set in and the gravel beds were allowed to accumulate. In some cases the mountain edge or escarpment receded considerably and the talus must therefore have receded with it, thus giving rise to a wider extension of the terraces. But it must be remembered that the formation of this conglomerate was by no means confined to this plain. Whenever conditions are favourable, the same thing happens. I need only mention a single example, that of Maoshan, where the limestone conglomerate some 50 metres thick forms the forehills on the eastern slope of the mountain which is probably a fault escarpment.

III Physiography.

GENERAL DISCUSSION:

The region under study may be regarded as a coastal region and consists of the Yangtse delta and a belt of hilly country west of Chinkiang which, in the south, is linked up with the mountains of S. Anhwei. The hilly belt consists of isolated hills or groups of such, but the area between is almost everywhere filled with loess which sometimes forms watersheds. Between this belt and the Fanch'ang and Chinghsien Hills there is an extensive depressed area occupied by large shallow lakes. In the delta region island-like hills are found scattered here and there.

The hills in the middle hilly belts vary very little in elevation—most of them are 200—300 metres in height; only exceptionally it rises over 500 M. The S. Anhwei mountains have one high range—the T'ienmushan in Chekiang which is considerably over 1,000 metres, but most of the summits in this massif are under that height. The rivers have not only dissected the hilly belt with its loess terraces but also penetrated far into the mountains so that alluvium occurs not very far from the valley head, and in all cases the passes that form watersheds are very low. It is therefore an area of mature erosion, and, looked upon as a whole, it seems to have been buried twice, once under the loess and the Tat'ung conglomerate, and another time by the recent alluvium.

Short Descriptive Analysis.

PLAINS AND VALLEYS:

The greatest plain is formed by the Yangtse delta which is roughly east to a line drawn from Hangchow through Chinkiang to Yangchow (揚州). Numerous streams come down from the hilly region to the west of this line, but they run only a short distance in the hilly country where they have a proper valley. As soon as the plain is reached, they lose their individuality, and are obscured among the innumerable canals and crosscuts, so that every one of

them has more than one outlet either to the sea, the master stream, or the lake. The mountainous valleys are also of considerable width especially the portion that runs through loess country; even in the upper reaches not far from the valley head, 400 to 500 M., is a common width for the valley floor. Within this delta area are numerous large, comparatively shallow lakes which have an important influence on the scenery and the population. On the northern side of the Yangtse River a belt of swampy land extends from Huaianfu (淮安府) southwards along the line of the Grand Canal right to the Yangtse; the lakes of Tatsung (大縱), Paoying (寶應), Kaoyu (高郵) and Shaopo (邵伯) form almost a continuous sheet of water. On the southern side, a line joining the district cities of Ch'angshu, Ch'ingp'u (青浦), Chiahsing (嘉興), Huchow, Ihsing, Liyang, Chint'an (金壇), Ch'angchow (常州) and the hills southwest of Wuhsi, following the northern shore of the T'aihu to Soochow, encloses a continuous lake area. The drainage system of these lakes is also complicated, for every lake has more than one outlet.

West of Chinkiang, the Yangtse runs between more or less well defined ranges, so its flood plain is of course limited, but as soon as the Anhwei border is reached, we have another low area occupied by large shallow lakes. In Northern Anhwei we need only mention the smaller lakes in Hochow (和州) between the mountains and the Yangtse, but in Southern Anhwei it is more extensive; the Lakes of Shihch'iu (石臼), Kuch'êng (固城), and Nanyi and the low land between Ningkuofu and Wuhu form also a continuous plain. Four important rivers descend from mountains in the south, the Yuanch'i (水西) from Nanling, the Ch'ingyikiang (青弋江) from Chinghsien, the Chüch'i (句溪) from Ningkuo and the Langch'i (郎溪) from Chienp'ing and Kuangtê.

The first has its outlet at Luchiang (魯港) above Wuhu, the second at Wuhu and the third and the fourth at T'aip'ing (太平), but the same process of anastomosis takes place here as in the delta, so that starting from the head of navigation of any one of these four, it is possible to reach any one of three outlets. In the plain these rivers meander extensively, but in the mountains, they have well defined valleys. The descent from their head waters is always gentle, and alluvium extends up very nearly to the water-shed. These valleys have a width varying from 300 M. to one kilometer—the Tungho (東河), a branch of the Chüch'i, which has its head at Ch'iench'iukuang, has a valley 900 M. wide at a point fifty kilometres from the pass.

Between the delta and this basin, only two important streams need be noticed; the one coming from Northern Anhwei and meets the Yangtse south of Liuho (六合), the other gathers the waters from Chüyüng, and Lishui and empties itself at Nanking. The former has a wider flood plain cut out in the loess, but has its head water in the hills that form the watershed between the Huai (淮) and the Yangtse, whilst the latter has a more limited flood plain also cut in the loess, but the longest head stream has cut back so far that it is only separated from the waters that flow into the Shihch'iu Lake by a very low and narrow ridge.

MOUNTAINS AND TERRACES:

The mountains have a distinct lineal arrangement of heights so that parallel chains on all scales are recognisible, but these chains do not run continuously for any distance, as they are often cut through by valleys. Only the Border Hills form a continuous massif, but it is cut through between Kuangtê and the market town of Ssü-an in Ch'anghsing so that the range of hills forming the boundary between the three provinces Kiangsu, Anhwei and Chekiang, is completely isolated.

In the main massif one dominating ridge, the Langshan (郎山)-T'ienmushan range, towers above all; the higher summits are considerably above 1,000 M., and the pass of Ch'iench'iukuang is 400 M. above sea level. The range ends in the N.E. in the well known Mokanshan group, the summits of which are 400—600 M. high. On both sides of this axis run the minor ranges in which there is very little difference in elevation, which varies from 300—500 M., with most of the passes below 200 M. above the sea level.

The hills between the T'aihu Lake and Kuangtê form the boundary between the three provinces. The arrangement of the higher summits coincides nearly with the provincial boundary lines, forming a T-shaped ridge. On this ridge the highest peaks, the Wut'ungshan and Kutseshan (鼓子山) are over 500 M. high, but many of the passes are quite low and most of the summits are below 400 M. The isolated hill of T'ungkuanshan just south of Ihsing city is probably also more than 400 M. high. The hills between this group and the Nanking ranges, are low hills more or less completely separated from each other—the *longest* range, the Maoshan and its southern extension, is directed N.—S., and the summits vary between 200 and 300 M. The hills to the east of this are mostly about 200 M. high—the highest mass, the Tunglüshan (東驢山) being 310 M.

The Nanking range is on the whole higher than the last group and the arrangement of heights more regular. The great majority of peaks are between 300 and 400 M. the highest point, the Chungshan near Nanking is 449 M. The volcanoes opposite Nanking on the N. side of the river have extremely constant heights, being all about 200 M. The hills in N.E. Anhwei, partly cut through by the Tientsin-Pukow Railway are less known, but they appear to be regular ridges directed E.—W. with an average height of not more than 200 M.

Of the isolated and scattered hills in the delta, the Soochow and Wuhsi group are the highest. Here the highest points are just over 300 M. The other groups are much lower, no point being higher than 150 M.

With perhaps the exception of some of the hills formed by granite and intrusive porphyries, practically all the summits and ridges are well-rounded: rugged forms are extremely rare. The mountains of Southern Anhwei do occasionally present a wild and picturesque aspect, but even here it is due often to the wild growth of vegetation, or to certain local tectonic feature, for example, the escarpment of a fault. On the whole the scenery is decidedly soft in character.

The peculiar feature of the region as distinguished from the rest of the Yangtse is the occurrence of terraces formed either by the Tat'ung formation or by the loess. The former is predominant in the foreground of the Southern Anhwei mountains, whilst the latter covers the whole area between the longitude of Chinkiang and T'aip'ingfu. Sometimes the two occur together, the conglomerate underlying the loess. These terraces are usually 30—40 M. above the plain and are well dissected by streams—especially those formed by the loess which has been cut into complicated forms. (See Plate II.). Sometimes on the loess terrace are numerous flat, round heads slightly above the level of the terrace. Both the loess and the conglomerate may extend over the present watershed—especially the former which is often the only barrier between two systems of drainage.

Influence of Folding and Faulting.

INFLUENCE ON RELIEF:

The influence of folding on relief is still visible; as we have seen, the heights have all more or less a lineal arrangement so that the mountains are true parallel ranges. Erosion has however brought about profound

changes on the topography. It is true that the parallel ranges still indicate a folded structure, but the relative height of these depends not so much on the original structure as on the relative hardness of the rock. Anticlines formed by the softer coal series no longer have the former elevation in respect to the surrounding units. On the other hand synclines formed by hard rocks often become prominent hills of which the coalfields of Ch'anghsing and Kuangtê are typical examples. In fact rock character is now the dominating influence in determining the height of any ridge. The highest range, the Langshan-T'ienmushan system, owes its elevation partly to folding, but partly to the fact that it is largely composed of granite and intrusive porphyry. Almost all the hills between 450—500 M. are formed by the hard quartzite S_3, the majority of the hills between 300—350 M. are formed by the harder kind of limestone, whilst the Tungt'ing sandstone forms hills between 200—300 M. The coal series, being the softest among the folded rocks, always occupy valleys and low grounds irrespective of their original structure.

Faulting must have had a great influence on the landscape, but most of the direct effects have been obscured by subsequent erosion. Very few fault escarpments are recognisable as such. The eastern slope of the Maoshan range is an example of the exceptions. Even here the escarpment must have greatly receded. More usually faults can only be seen in the structure. Often two sides of a fault with a throw of 400 M. or more are now at the same level. This is true of most faults, but a few which had a regional importance are still powerful features of the scenery, for example, the lakes of Southern Anhwei formed by two systems of faults are still depressions of considerable importance.

INFLUENCE ON STREAMS :

If the influence of the tectonic movements on the streams has not been done away with by the opposing influence of erosion, we would expect, in a folded region like this, that the rivers occupy either the synclinal folds or some lines of weakness caused by faulting. Such streams are of course consequent. The master stream, the Yangtse river, is in fact a wonderful example. Beginning from Fanch'ang, we see that the river runs E.—W. coinciding with the strike of the Fanch'ang Hills. Near Wuhu the rocks strike N.—S. and so is the course of the river. From T'aip'ingfu to Nanking the strike of the sedimentary rocks is N.E.—S.W. and accordingly the river

also changes into that direction. Further down the stream, the Nanking-Chinkiang Hills strike E.—W. and the scattered hills of Kiangyin and Ch'angshu, W.N.W.—E.S.E., which directions are in absolute concordance with the river. We know too little about the geology of the hills on the northern bank of the Yangtse to form a definite opinion as to the origin of the Yangtse valley, but the remarkable coincidence of the river course with the strike of the country, together with the dissimilarity of the geology of the hills on the N. and the S. banks, point out clearly a tectonic line of first importance. When we remember the proximity of the Arc of Huoshan, the conclusion is almost certain that the Yangtse river, from Fanch'ang downwards at least, follows a line of weakness; it is therefore a consequent stream.

In the tributary streams the consequent features are much less evident. Richthofen noticed § that the courses of the rivers follow the parallelism to a limited extent only. "It is a peculiarity of these rivers," he said, "that nearly every one among them will follow a longitudinal depression for a short distance only, then, with a short turn intersects one of the two enclosing ridges at nearly right angles to its trend, until it reaches the next depression". Now in modern terminology, we may say that these rivers are consequent only in part, for some of them have been beheaded and others have increased their length by capture, so that a complicated system of drainage results. Similarly many streams that run from the upthrow side of a fault have cut back so far as to be joined up with portions of the streams far behind the original fault line.

No back cutting or capture however can explain the present arrangement of some of the rivers. The important tributaries in southern Anhwei flow from the southern mountains northwards right across the direction of the strike, traversing on their way often half a dozen folds. At the present stage of erosion, it is not possible to explain it except by supposing that these rivers are antecedent streams whose direction of flow has not been greatly affected by the slow process of folding.

SURFACE OF EROSION BEFORE FOLDING:

What was the relief before folding took place? All evidence seems to point to the conclusion that it was either a peneplane or surface of mature erosion. For in common with the other parts of the Nanshan, there is a

§ Letters p. 63.

remarkable unformity in the relative height of the summits, § and in the analysis of the mountains we have further seen that the different heights are mostly the result of the difference in rock character, and there seems to be a constant relation between them. Had the relief before folding been mountainous, its traces could not be so completely obliterated.

Changes of Climate.

EVIDENCE OFFERED BY THE TAT'UNG FORMATION AND THE LOESS:

As we have already explained that if the theory of the origin of the Tat'ung conglomerate is a correct one, then we may mark the period after folding as the beginning of a change of climate, for such extensive gravel could never have been formed under the present climatic conditions, as the abundant monsoon rain would have washed away these pebbles far from their source. It was however only the *beginning* of a slow change. There was, during that period, still a wet season with sufficient rainfall to carry on the work of erosion; a climate similar to that of N. Chihli at the present time would suit the case very well. As the conglomerate is everywhere overlaid by the loess, which is undoubtedly the product of the steppe condition, we may suppose that the climatic change went on a step further; there was no longer enough water to do any work, but dry weathering and wind deposition took its place. The thickness of loess in this region must have been much greater than it is now, therefore the time of deposition fairly prolonged, but gradually another change in the opposite direction set in and the present condition began. The erosion in the conglomerate and the loess shows that since then considerable work has been done, as valleys 30—40 M. deep have cut into the originally flat terraces.

EXPLANATION OF THE DISTRIBUTION OF LOESS:

The distribution of loess in the Yangtse valley requires an explanation. No loess is known to occur west of the longitude of Tungling (銅陵) or south of the latitude of Huchow. The southern limit may perhaps be explained by the limit of climate, but it is more difficult to understand the

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§ Letters p. 62.

absence further up the river. I think the explanation lies in the relief at the time of loess formation. We may assume that the character of the land surface at that time was not so very different from the present, and the eastern extension of the Ch'inling (Tsingling) Mountain stopped short at the Arc of Huoshan which was probably somewhat higher than it now is, so that the area southwest of this range was protected from the north wind which was mainly responsible for bringing over the loess material. Similarly the southern limit is easily understood; the massive mountains of Southern Anhwei with the higher axis of Langshan and T'ienmushan would be a formidable barrier to the same wind.

The cause of the climatic change cannot be explained here, but it is possible that the formation of high ranges shutting out the moist S. and E. winds may have contributed something towards the change.

Sinking.

EVIDENCE OF SINKING:

Richthofen clearly recognised the fact that Eastern China has been undergoing a slow subsidence, but he contended § that N. of Ningpo the coast was rising. No evidence was given for either opinion, but it was suggested that as a consequence of the latter, the great plains of Northern and Middle China gradually diminished in width as they approached Ningpo. I believe such a conclusion is quite unwarranted. The great plains are deltas formed by the two great rivers, the Yangtse and the Huangho and have nothing whatever to do with the rising of the land. In fact B. Willis §§ expressed the opinion that the northern coast had been sinking. Physiographically there is clear evidence that the whole eastern coast has been undergoing the same process. The rocky coast from Southern Chekiang to the east of Kwantung contains numerous fiord-like arms of the sea which are nothing but drowned valleys. In the delta region isolated hills occur in the midst of alluvium which are nothing but buried mountains. It is uncertain whether this subsidence is still going on at the present time, but there can be very little doubt that it has been taking place in quite recent geological time, as many of the physiographical features due directly to this movement have not been sensibly modified by subsequent erosion.

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§. Letters p. 65 and "China" Vol. III p. 405.

§§. Researches in China Vol. I. p. 199.

EXTENT AND RATE OF SINKING :

It is difficult to estimate the extent of the sinking ; more information about boring sections in the delta is very desirable. According to Lamprey, rounded pebbles are met with at 248 feet. Already at 243 feet limestone nodules mixed with sand are met with. I think it is probable that this gravel bed represents the bed of some river which must have been at that time not far from the hills, for, as Shanghai is situated to-day, far away from any mountain, no such gravel can be formed. Thus it furnishes an additional proof that the coast has been sinking and perhaps 250 ft. is the extent.

The rate of sinking is difficult to determine, but I have the impression that it has been extremely slow and perhaps unequal in different periods. It is possible that on the average the power of deposition of the mighty Yangtse was more than enough to counterbalance the effect of sinking, as it must have been in very recent times, because the delta has been gaining at the expense of the sea.

EFFECT OF SINKING:

One would naturally expect that in a sinking coast the sea must gain upon the land in such a way that large areas formerly forming the coastal plain become under water. This must have happened more than once in the Yangtse Estuary, but the Yangtse river with its unparalleled power of deposition is a constant agent working in the opposite direction. It is probable in fact that though the total extent of sinking is 250 feet, nowhere in the delta has ever been under sea water to that depth at any time. The effect on the scenery is however the same as if it had been so, hence the isolated hills now scattered in the plane are true buried mountains. In general, this sinking, if it extended far inland, must have lowered the average height of the mountains, and deepened the floor of the basins in respect to the sea. Hills with low watersheds appear now completely separated from its neighbour, valley floors appear also wider and the land seems to be more mature than it would be otherwise.

IV. THE HISTORY OF THE YANGTSE ESTUARY.

Theory of Ancient Mouths.

The question whether the Yangtse had more than one outlet to the sea is one of great interest. In the book "Yükung" (禹貢) the oldest work on geography, supposedly written by the Emperor Yü about 4,000 years ago, it is said that there are three "Kiang." It seems therefore natural to suppose that the Yangtse River had two more mouths in ancient time. It is more difficult to identify them with any existing stream. I will here first give the text and then commentaries made on them by Chinese and European scholars, and then describe my own observations and conclusions.

THE TEXT OF THE YÜKUNG:

After describing the course of the Yellow River or "Ho", the book "Yükung" goes on to say:—

"The mountain of P'anchung (嶓冢) gives origin to the Yang (漾) River which, flowing eastward, becomes the Han (漢). Further east it is the river Ts'anglang (滄浪). Passing the Sanshih (三澨) it reaches the Tapieh (大別) and, running south, enters the Kiang (江). Going eastward it joins the swamps and forms the P'êngli (彭蠡) (Poyang Lake), whence eastward it becomes the North Kiang and enters the sea.

The Mountain Min (岷) gives origin to the Kiang, which is distinguished as the T'o (沱) to the east. Eastward again it reaches the Li (澧) (river from Hunan) after which it passes the Chiukiang (九江) (supposed to be the Tungt'ing Lake) and arrives at Tungling (東陵). Flowing eastward and winding to the north, it joins the Hui (滙), (probably swampy land about Huangchow (黃州). Further east it becomes the Middle Kiang and enters the sea."

No special mention was made of the South Kiang, though evidently it must have existed.

In another passage describing the ancient province of Yangchow (roughly—Kiangsi, Anhwei, Kiangsu and Northern Chekiang together), it says:—

"After the three Kiang had entered (usually supposed to mean entered the sea), the Chentsê (震澤) (T'aihu Lake) became fixed".

COMMENTARIES :

The text quoted above has given rise to numerous controversies as to the identification of the three Kiang. Briefly the various theories can be classified into three groups :—

(a) Those which suppose that the three Kiang represent three separate branches of the Yangtse originated somewhere below the Poyang Lake. They all find support in certain passages in the Ch'ienhanshu (前漢書), or History of the Early Han Dynasty by Panku (班固) who lived soon after the beginning of the Christian era, and in the Shui Ching (水經), or "Book of Rivers" supposed to be written in the same period. These passages may be translated as follows :—

Text from "Ch'ienhanshu," (in the chapter on geography) :—

Speaking of Wuhsien (吳縣) (modern Soochow), it says, "the South Kiang is in its south, entering the sea to the east, forming one of the rivers of (the ancient province) Yangchow." Speaking of Pi-ling (毘陵) district (modern Ch'angchow), it says :—"the Kiang is in its north, entering the sea to the east, forming one of the rivers of Yangchow." Speaking of Wuhu (the same as modern Wuhu), it says :—"The Middle Kiang comes from the southwest, goes to Yanghsien (陽羨) district (modern Ihsing) and enters the sea, forming one of the rivers of Yangchow." Speaking of Shihchêng (石城) (modern Ch'ihchowfu 池州府) it says :—"the Fênshuikiang (分水江) receives the Kiang for the first time and going eastward to Yüyao (餘姚) (modern Shaohsing 紹興), it enters the sea after traversing 1,200 li."

Text from Shui Ching :—Speaking of the lower course of the Kiang it says :—"Arriving at Shihch'êng (Ch'ihchowfu), it branches into two, the one flows northeastward and passing N. of Piling (Ch'angchow), forms the North River ; the other flows eastward to Yüyao district in Hueichi (會稽) (ancient prefecture including Soochow and Hangchow) and enters the sea."

Now the above texts are capable of two interpretation, hence two views have been held.

(1) One school supposes that the Fênshuikiang of Panku, which is evidently the same as the second branch mentioned in Shui Ching, is the same as the South Kiang. The commentator on the Shui Ching, Litaoyüan (酈道元) who lived towards the end of the 5th century A.D. first adopted this view. According to this, the Yangtse is the North Kiang, the supposed

branch from Wuhu via Kaoch'un, Ihsing and T'aihu to the sea is the Middle Kiang and the third supposed branch from Ch'ihchowfu via Ningkuofu and Kuangtêchow is the South Kiang.

(2) This school refuses to accept the view that the Fênshuikiang of Panku is the South Kiang, which is supposed to be the Sunkiang (i. e. the so-called Soochow Creek of foreigners). But in other respects it is the same as (1).

(b) Those which suppose that the three Kiang of the ancient province of Yangchow are not to be confused with the North and the South Kiang; they identify the former with waters other than the Yangtse River. Here again are also two schools.

(1) One school supposes that the three Kiang are the Sunkiang (Soochow Creek), the Loukiang (婁江) (a river north of the first), and the Tungkiang (東江) (which is sometimes identified with the Whangpoo). All of them are outlets of the T'aihu. This view is based on the occurrence of the name of the ancient village of Sankiangk'ou (三江口) (i.e., the mouths of three Kiang) 30 li S.E. of Soochow in the Wutichi (吳地記), or the Geography of Wu, written in the 9th century.

(2) The other school thinks that the three Kiang are the Sunkiang, the Ch'ient'ang, (錢塘) and the Fuyang (富陽), a tributary of the second river. This view was proposed by Wei Chao (韋昭) who lived in the 3rd century A.D., without any definite reason.

It is to be noticed that no explanation is offered for the North and the South Kiang.

(c) This is a combination of (a) and (b), for it supposes that the Yangtse is the North Kiang, the Sunkiang or Soochow Creek the Middle Kiang, and the Chekiang (the Ch'ient'ang) the South Kiang. This theory refuses to accept the supposition that water can pass from Wuhu to the T'aihu via Kaoch'un, and the Sunkiang is therefore merely regarded as an outlet of T'aihu. It is based on the present geographical features, and was first proposed by Kuop'u (郭璞) in the latter part of the 3rd century.

(d) This supposes that the three Kiang are the three upper principal tributaries of Yangtse: the Han is the North; the Min, the Middle; and the Kankiang (贛江) of Kiangsi, the South River.

This view was suggested by Chengk'angch'eng (鄭康成), of the 2nd century A. D. in his commentary of Yükung, but his actual text is somewhat vague and ambiguous.

VIEWS OF EDKINS AND RICHTHOFEN :

The question was first made known to the Europeans by Legge in his "Chinese Classics", but as he even doubted the authenticity of the Yükung, no particular interest was attached to the problem. It was J. Edkins § who first adopted the view explained in a (1). From our knowledge of geography, it is however quite evident that this theory is, in part at least, quite inadmissible, as there can be no continuous course from Ch'ihchow to the T'aihu via Ningkuo and Kuangtê because there are mountains of considerable height between them. With admirable critical power and real scholarship Richthofen §§ proposed a modification. He practically combined the theories a and c; according to him, the Yangtse is the North, a branch from Wuhu to the T'aihu Lake the Middle, and the Ch'ient'ang river the South Kiang. A continuous water communication from Wuhu to the T'aihu Lake via the town of Tungpa in Kaoch'un does exist, as it is indicated on most of the Chinese maps, so his theory is extremely plausible. But another competent geologist, Loczy §§§ disputed his conclusion, and on his map a pass formed by loess was drawn between Kaoch'un and Liyang. Now as neither Richthofen nor Loczy had ever been to the region, it seems desirable to settle the question by actual observation. With this object I set out from Chienp'ing to Tungpa.

OBSERVATION FROM CHIENP'ING TO YUSHAN (游山) VIA TUNGPA : (See Fig. 27).

The city of Chienp'ing is situated on the right bank of the Langch'i river which receives its water from two branches, one from Kuangtê, the other from Shihchiehtu (誓節渡). In the east it is some 30 li from the mountain, but the real alluvial plain extends only about ten li from the city, the area between the plain and the mountain being occupied by typical loess terraces. The distance from the southern mountain is probably similar, but in the west the plain is joined up to the Nanyi lake by the Langchi river.

§. 'On the ancient mouths of the Yangtse Kiang" Royal Asiatic Society 1859.

§§. China Vol. I p. 291—300.

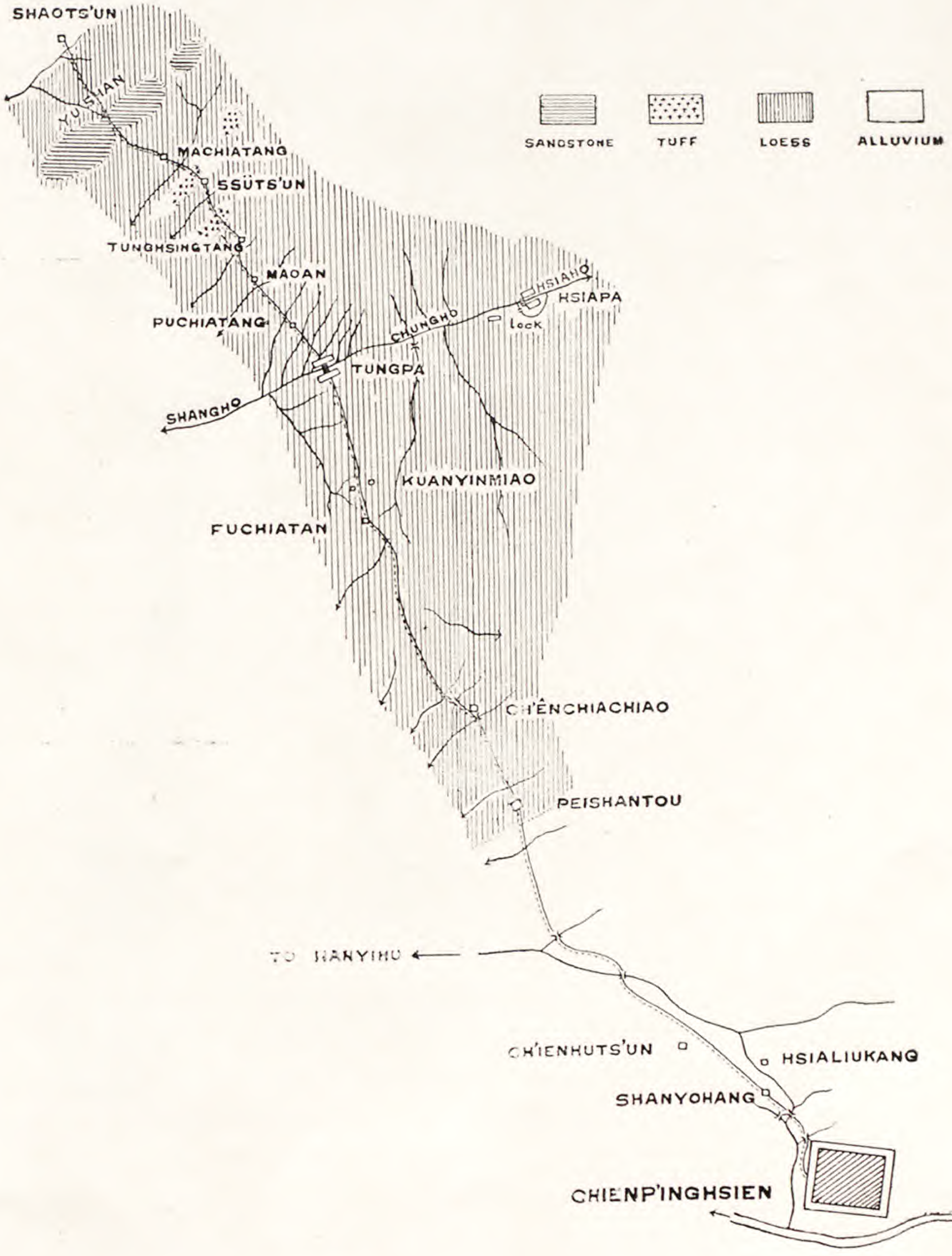
§§§. "Die Wissenschaftlichen Ergebnisse der Reise des Grafen Béla Széchenyi" Vol. I. p. 739.

Going from the city northeastward, the road is on a high embankment on the left side of another river, coming from the east. This is crossed by a wooden bridge about 15 li from the city, whence the road still follows the N.W. direction, whilst the river goes westward to the Nanyihu. The area so far traversed is very swampy, with numerous pools and crosscuts connecting the water together, but henceforth the plain becomes less well watered, and another 8 li of marching bring us to the foot of a loess ridge, on which is situated the village of Peishant'ou, which is officially written 北山頭, i.e., the North Hill Head, but the villagers prefer to write it 百山頭 or the Hundred Hill Heads, because from here northwards, there is an area entirely occupied by loess which forms well dissected terraces as usual, but here are numerous small flat-topped, perfectly round heads rising a few metres above the level of the terrace (See Fig 28 and Plate 12). A little more than 4 li further, the village of Ch'engchiachiao (沈家橋) indicates the boundary between the province of Anhwei and Kiangsu. The road goes up and down along imperceptible slopes till a ridge about 4 li from Tungpa is reached, which is the highest point along the road, being about 35 M. above the plane of Chienp'ing (See Fig 28). A short descent brings us to the flourishing town of Tungpa, which is built at the foot of a loess cliff, and is probably some 15 M. below the highest point mentioned above. Villages all along the road are rather few and far between and generally poor because the terrace itself is not cultivated, but only the valley floor of the ravines offers some ground for growing rice.

Going from Tungpa always in the northwest direction, we find exactly the same scenery on the other side of the Tungpa river. Only the road here does not cross the higher part of the terraces, which is to east of the road, hence the ravines are wider and the ridges separating them are lower. When we arrive at the village of Tunghsingt'ang (東興塘) eight li from Tungpa, the ravines look more like rivers and on the ridges we find beneath the loess a much decomposed, soft, and bedded rock, originally a volcanic tuff, giving rise to a pinkish clay. This occurs in fact in the whole region between Tunghsingt'ang and Shihch'iu Lake, for the most part buried under the loess but occasionally it forms low hills 10—20 M. above the level of the terrace, for example, the Hsitseshan (喜子山) near the village of K'ungts'un (孔村). Between the latter and Tunghsingt'ang is the Yushan ridge consisting of hard sandstone, forming the watershed between the Shihch'iu and the Kuch'êng lake.

FIG. 26.—Route Sketch from Chienp'ing to Yushan.

Scals 1:200,000



THE TWO BARRIERS :

As the Middle Kiang has been supposed to pass through Tungpa, it is important to describe the region in detail. The town to Tungpa is situated on a river, which flows W.S.W. into the Kuch'êng lake and ten li E.N.E. from Tungpa is the town of Hsiapa (下壩) where the water flows E.N.E. to Liyang. Between the two places there is a continuous channel of water, but a massive dam at each place shuts the water off from both rivers beyond. The dam at Tungpa is known as the Shangpa (上壩) or upper barrier, the river to the west, the Shangho (上河); that at Hsiapa has the same name as the town, and the river to the east, the Hsiaho (下河). The strip of water between is termed Chungho (中河).

The upper barrier or Shangpa is a prism-shaped stone work with very slanting sides, consisting of a series of steps (See Plate 14). At the time of my visit, the water on both sides of the barrier had practically no difference in level, the top of the barrier being only 2.5 M. above water. The horizontal distance from the water edge on the east side to that is about 40 M. whilst the length of barrier across the river is rather less than 30 M. Some of the slabs are of limestone, but most of them are of granite.

The lower barrier, or Hsiapa, is similar in form, but is longer and narrower. The N.—S. distance is about 60 M., but the horizontal distance between the water edges is only 35 M. Again, the water level is very different —the water on the east side it is some 7 M. below the top of the barrier, but on the west side it is only 2.5 M. It is slightly better in repair, and all are built with granite slabs nearly 2 M. long, 0.5 M. broad, and 20 cm. thick. According to the local records, the main body of these two barriers is filled with a cement formed by mixing two parts of clay with one part of lime, besides driving strong wooden piles in the middle and at the base of the two sides.*

The Chungho, or Middle River, receives water from the loess terraces on both sides where there are half a dozen ravines running into it. An outlet is provided for on the south side some 60 M. west of the lower barrier. This goes round the town of Hsiapa and joins to the Hsiaho just E. of it. It is guarded by a sluice so as to provide sufficient water in the Chungho for ships going from one barrier to the other. Both banks are formed by high loess cliffs, the top of the terraces being about 30 to 40 M. above the bed of

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* The levels given indicate that the water would flow through if the barriers did not exist.

the channel (See Plate 13). The distance between the cliffs is on the average about 50 M. ; the part 4 li E. of Shangpa is the narrowest, being less than 40 M., but it gradually widens out to nearly 70 M. near Hsiapa. The narrowest part has also the least water—in some places the water is so little that ships can go through it only by being towed with ropes, and then, only one at a time. The great part of Chungho is also remarkably straight.

THE HISTORY OF CHUNGHO AND THE BARRIERS:

From the above description, I think it is evident that the Chungbo is an artificial canal—the narrowness of its valley, the straightness of its course and the surrounding high loess hills all point out unmistakably to this conclusion. No arm of the Kiang however small could possibly have gone through here without leaving recognisable signs of its presence. This has been in fact the view of many Chinese writers well acquainted with the country. Moreover the date of construction is known—it is certainly one of the oldest canals in the world, for there is reason to believe that it is to be identified with the canal made by Wuyüan (伍員) of the Kingdom of Wu (吳) (Kiangsu and part of Anhwei) about 510 B.C. for the purpose of conveying supplies to the troops who were sent to attack the neighbouring Kingdom of Ch'u (楚) Hupei, Hunan and Kiangsi) hence the river is known in literature as Hsüch'i (胥溪) which means the river of Hsü because Wuyüan was also called Wutsehsü (伍子胥). Many additional evidence are at hand to show that the route from Wuhu to Liyang was the favourable route of war with these early feudal lords. From the Tsochuan (左傳), we know that in 571 B.C. the kingdom of Ch'u took the city of Chiutse (鳩茲) (modern Wuhu) from the Wu Kingdom, and went as far as Hêngshan (衡山) (modern Huchow). In 480 B. C. a general of Chu attacked Wu again and took the city of T'ungjui (桐汭) (modern Chienp'ing). The modern town of Kuch'êng from which the lake takes its name was first established about the same time by the kingdom of Wu as a fortress against the Ch'u. So Wuhu, Chienp'ing and Kuch'êng were then important fortified towns on the frontier, and there is no wonder that they spared no effort to improve the communication in the immediate rear. The original watershed must have been less than 30 M. high and not longer than 3 or 4 li, so canal making was a comparatively easy matter, especially as the loess is a very soft material to excavate. The usefulness of the work is well proved by the numerous ships that still carry goods from one barrier to the other; much



PLATE XIII.—The Chungho near Tungpa, Kaoch'un, showing the loess hills on both banks.

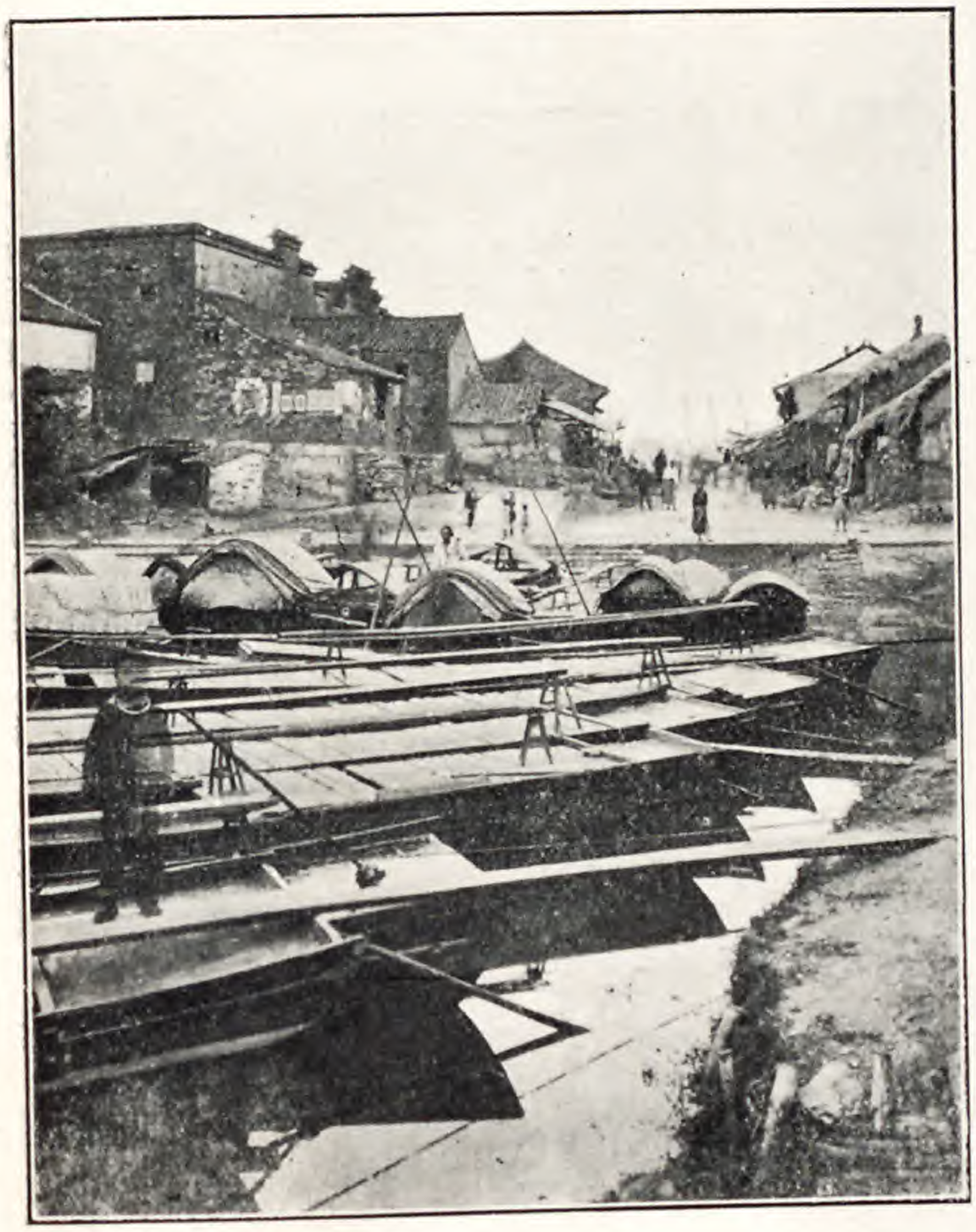


PLATE XIV.—The Shangpa from the east side.

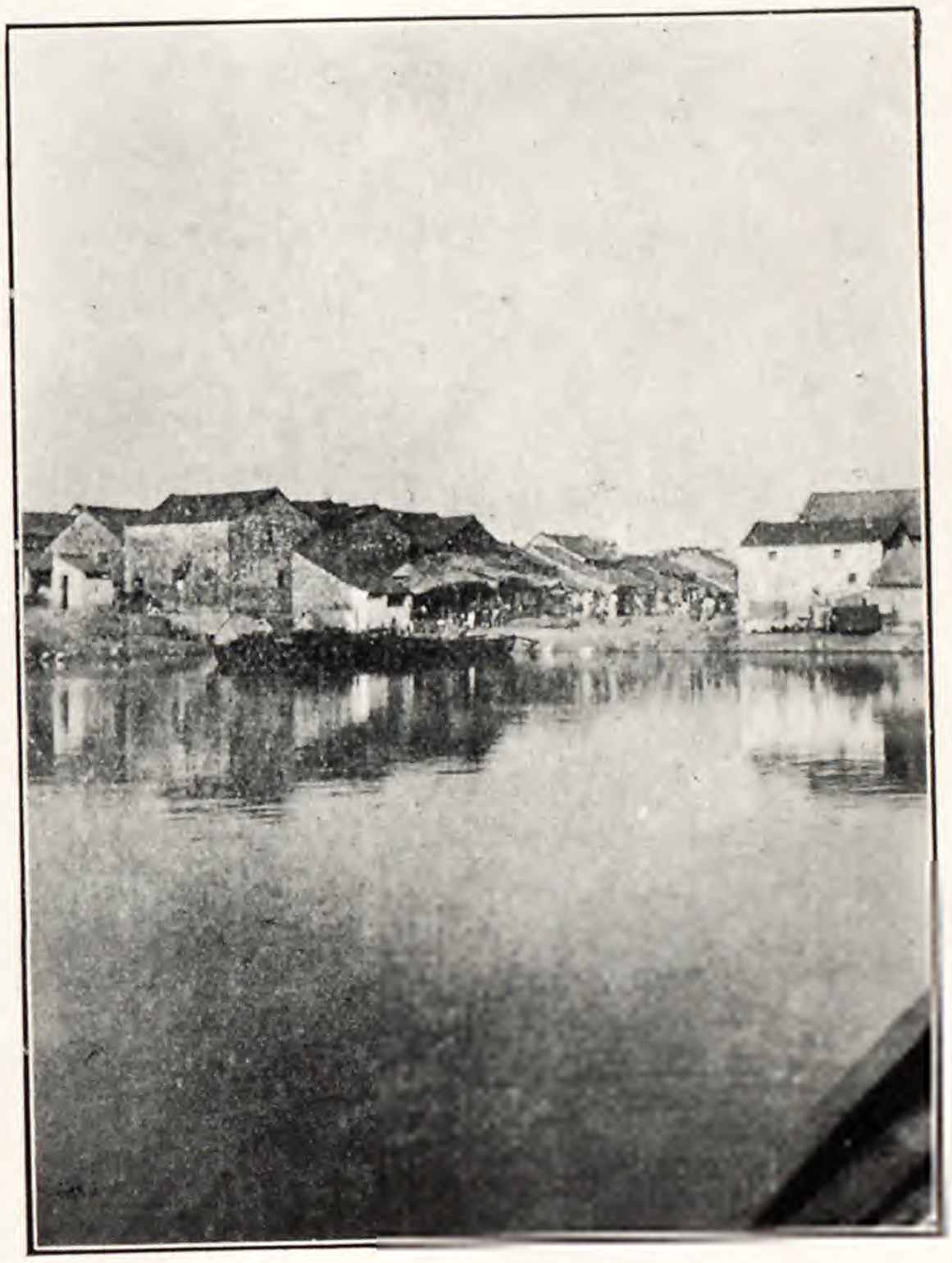


PLATE XV.—The Hsiapa from the west side.

more useful it must have been before the barriers came into existence, as it put the two rice-producing districts into continuous water communication—the tea of Anhwei could go to Kiangsu and the silk of latter to the former without going through the more dangerous navigation on the mighty Yangtse—not that the Chinese did not master the art, but the junks that are fitted for the great river cannot go inland, and the Yangtse is far too dangerous for the smaller craft that do duty in the small rivers and canals. The same kind of canal building is seen in one in the south of the Lishui district. In the year 1392 when Nanking was the capital of China, a canal was cut through the watershed north of the village of Hunglanpu (洪藍埠) so that the water of Shihch'iu lake could flow into the Chinhuaiho (秦淮河) that goes from Lishui to Nanking in order that the products of S. Anhwei and Kiangsu could go to the capital without risking the Yangtse. This canal was called Yentseho (胭脂河) or scarlet river, owing to the pink colour of the decomposed tuff into which the canal was cut. When the capital was removed to Peking, the canal fell into disuse but on most maps to this day, Ch'inhuaiho is represented as in communication with the Shihch'u lake. That canal has a short tunnel at the summit of the pass, and is now dry.

The Chungho canal made in 510 B. C., remained open throughout ten centuries, and then it became blocked up and five barriers known as Wuyen (五壝) were erected. The date of the erection is uncertain, but in the year 894 A. D. the canal was again open to traffic and remained so till the Sung dynasty (10—12th century). The district of Kaoch'un was then very prosperous owing to the gradual draining of the lakes, but the districts round the T'aihu Lake suffered frequent inundations, and it was frequently proposed in the 11th century to rebuild the dams so as to lessen the supply of water, but apparently the proposal was never carried out. It is known however that the Chungho became blocked up in the Yüan (元) dynasty (1264—1367), but was re-opened in 1392 by the first Ming emperor to put Nanking into canal communication with the rice producing districts. In 1403, the T'aihu country was badly flooded and a barrier was erected in Tungpa to keep off the water of Anhwei. In spite of it a great flood broke through in 1441 and the Soochow districts were badly flooded, so the barrier was rebuilt with stone, and very stringent regulations were made to keep it up. It was further strengthened in 1512. In 1556 the inhabitants of Hsiapa erected the lower barrier in order to make the ships stop there so that the villagers could gain

something for transferring the goods. The last breach of the barriers occurred in 1849, when both barriers had to be rebuilt.

It is on record that within 80 years after the construction of the Tungpa the rice fields in Kaoch'un decreased 30% in acreage; it is evident that, though the barriers have been beneficial to the lower districts to the east, the regions west of the them have suffered considerably. This is easy to understand because Kaoch'un has the lowest flood levels in S. Anhwei.

The following are the figures of maximum flood levels § referred to the Woosung Horizontal Zero:—

Ningkuofu	49.1 ft.	Shuiyang (village S.W. of Kaoch'un)	37.6 ft.
Ta Nanyihu	43.6 ,,	T'aip'ingfu	37.6 ,,
Wuhu	39.9 ,,	Kaoch'un	35.6 ,,

No exact figures for the two barriers or the area to the east are available, but I think the top of the two barriers is less than 10 feet higher than Kaoch'un, probably level with Kaoch'un flood level, whilst the level of the Hsiaho at the lower barrier in the month of highwater is 20 feet (say=16 W.H.Z.) or more lower than the crest of the barrier, hence the Hsiaho must be considerably lower than Kaoch'un. Again the Hsit'aihu §§ at high water during spring tide in the month of October i.e., in the month of high water, has a level of 8 feet above the Woosung Horizontal Zero. As I do not think there is any appreciable difference in level between the T'aihu and the Hsita'ihu, so Kaoch'un must be more than 20 ft. higher than the region round the T'aihu Lake. Had not been for the barriers, a considerable amount of water could have been discharged through this channel, because in the time of flood most of the water from the S. Anhwei rivers could go by this channel instead of flowing in to the Yangtse.

EXPLANATION OF THE THREE KIANG :

From the above considerations there can be no doubt that the passage from Kaoch'un to Liyang is an artificial one, so the theory that it represents the Middle Kiang, however plausible it appears, cannot be adopted. Thus theory (a) is to be discarded. What explanation can we then offer for the three Kiang ?

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§. I am indebted to Dr. Chatley for these figures.

§§. "Report on the Hydrography of Whangpoo."

We may say at once that theory (b) must be dismissed, for, in attempting to formulate an explanation, we must remember that the word "Kiang" used in Yükung was a *proper name*, then applicable only to the Yangtse, just as the term "Ho" was the name restricted to the Yellow River; the widening of the term, which means now a large river, came about very much later. Therefore the three Kiang of Yükung cannot be considered to be rivers other than the Kiang, large or small, and it is most unnatural to suppose that the outlets of the T'aihu should receive such a name. Moreover the Loukiang is merely a branch of the same river Sunkiang, and the Tungkiang can only be doubtfully identified with the Whangpoo.

Thus there are left only theories (c) and (d) to consider. Theory (d) looks very simple but it is difficult to reconcile it with the general meaning of the text, which certainly gives the distinct idea, that the North and the Middle Kiang are rivers *below* the Poyang (鄱陽) Lake. Again the same objection which has been applied to (b) holds true here—we cannot seek the North and the Middle Kiang outside the three Kiang in Yangchow, and the Han and the Min are both outside that ancient province.

I think that theory (c) seems most reasonable. There is considerable evidence that the Sunkiang or Wusungkiang was at one time much more important; the silting up of its channel, largely due to tidal action, occurred in comparatively recent time. On the other hand there is no reason to doubt that the Yangtse River and the T'aihu have always been in free communication as it is today. The large lake of Kohu (滆湖), also pronounced Hsienhu), between Ch'angchow and Ihsing was certainly once a part of the T'aihu, but is now separated from the latter by a wide stretch of alluvium. How has this been formed? The water flowing from the western lakes to the T'aihu would have all its sediment filtered and no longer capable of such deposition. It is much more probable that a branch of the Yangtse with its load of silt coming off north of Ch'angchow emptied itself into the N. W. corner of the ancient and larger T'aihu, and gradually built up a delta right across. In this way we would have an arm of the Kiang going through the lake and continuing eastward as the Sunkiang, forming the Middle Kiang.

The third or South Kiang is to be identified with the Ch'ient'ang because it is the only river that has sufficient water to deserve such a name. Moreover it has been more or less in free communication with the Yangtse, either via T'aihu or to the east of it. So it would not be unnatural to apply the name "Kiang" in this case.



Fig. 27.—Section from the Chienp'ing Plane to Tungpa.

Horizontal Scale 1 : 200,000
Vertical Scale 1 : 10,000

Growth of the Delta in historical time.

DATES OF THE ESTABLISHMENT OF THE CITIES :

In attempting to make out the growth of the delta in historical time the dates of the establishment of the cities offer very interesting and valuable information. Here is a list of the district cities in Kiangsu and part of Chekiang arranged in chronological order.

(1) Those in Kiangsu.

Name.	*Date of Establishment.*	*Remarks.*
P'ihsien 邳縣	2000 B.C.	A feudal state. Became district in 221 B. C.
Wuhsien 吳縣=Soochow	1122 B.C.	Capital of Wu Kingdom, City wall built in 500 B. C.
Wuhsi 無錫	1122 B.C.	Became a district in 221 B. C.
T'ungshan 銅山=Hsüchow	about 1000 B.C.	Pêngcheng (彭城) of Chou (周) dynasty.
Tanyang 丹陽	221 B. C.	District of Ch'in (秦) dynasty of the same name.
Muyang 沭陽	582 B. C.	Became a district in 205 B. C.
P'eihsien 沛縣	572 B. C.	In the Kingdom of Sung. 宋 Became a district in 205 B.C.
Wuchin 武進=Ch'angchow	560 B. C.	Estate of a prince in the Wu 吳 Kingdom. Became a district in 205 B. C.
Kanyü 贛榆	524 B. C.	Became a district in 205 B. C.
Such'ien 宿遷	515 B. C.	Capital of a feudal state. Became a district in 221 B.C.
Huaian 淮安	6th century B. C.	In the Kingdom of Wu. Became a district in 221 B. C.
Liuho 六合	,, ,, ,,	In the Kingdom of Ch'u. Became a district in 221 B.C.

Name.	*Date of Establishment.*	*Remarks.*
Kiangtu 江都—Yangchow	6th century B. C.	In the Kingdom of Wu. Became a district in 221 B. C.
Hsiaohsien 蕭縣	,, ,, ,,	Kingdom of Hsiao. 蕭 Became a district in 221 B. C.
Tant'u 丹徒—Chinkiang	,, ,, ,,	Became a district in 221 B. C.
Kiangning 江寧—Nanking	472. B. C.	In the Kingdom of Chu. Became a district in 221 B. C.
Kiangyin 江陰	about 340 B. C.	Became a district in 205 B. C.
Tangshan 暘山	221 B. C.	Capital of a Prefecture.
Fênghsien 豐縣	,, ,,	Became a district in 205 B. C.
Tunghai / Kuanyün —Haichow 海州	,, ,,	A district of Ch'in — called Chü (朐).
Chüyüng 句容	205 B. C.	A district of Han dynasty of the same name.
Lishui 溧水	,, ,,	A district of Han dynasty called Liyang.
Kunshan 崑山	,, ,,	A district of Han. But site to the N. of the modern city.
Ihsing 宜興	,, ,,	A district of Han named Yanghsien (陽羨)
Yench'êng 鹽城	,, ,,	A District of Han named Yentu (鹽瀆).
Lienshui 漣水—Antung	,, ,,	A district of Han named Hsiangfeng (襄賁).
T'aihsien 泰縣—Taichow	,, ,,	A district of Han named Haining (海寧).
Kaoyu 高郵	205 B. C.	A district of Han of the same name.
Ch'angshu 常熟	about 1st century A. D.	From 1st century to 283, residence of a salt Commissioner. Because a district in 283.
Nant'ung 南通—T'ungchow	about 400 A. D.	A district named Putao (蒲濤). The hill of Chünshan (軍山) is supposed to be known in the 6th century B. C.
Yüyao 餘姚	about 400 A. D.	A district of the same name.
Paoying 寶應	598 A. D.	District of Shui (隋) named Anyi (安宜).

Name.		*Date of Establishment.*	*Remarks.*
Chint'an	金壇	about 600 A. D.	District of Shui named Chinshan (金山).
Liyang	溧陽	620 A. D.	Originally part of a Han district
Yicheng	儀徵	682 A. D.	A district of T'ang (唐) named Yangtse (揚子)
Ch'ingpu	青浦	7th century A. D.	Known as Ch'inlungcheng (青龍鎮) Became a district in 1542 A. D.
Sunkiang	松江	751 A. D.	A district of T'ang.
Wukiang	吳江	909 A. D.	Originally known as Sunlingcheng (松陵鎮)
Shanghai §.	上海	1130 A. D.	Originally a sea port. Became a district in 1290 A. D.
T'aihsing	泰興	920 A. D.	Originally a part of T'aichow.
Hsinghua	興化	Beginning of 10th century A. D.	
Haimên	海門	955 A. D.	See Mr. Heidenstam's "Yangtse Estuary."
Suining	睢寧	1218 A. D.	A district of Chin (金) of the same name.
Chiating	嘉定	1222 A. D.	A district of Sung (宋) of the same name.
Huaiying 淮陰=Ch'ingho (Tsing Kiang pu)		1273 A. D.	A district of Sung dynasty.
Ch'ungming	崇明	1277 A. D.	The sand bank appeared in 620.
Ssüyang 泗陽=Taoyüan		13th century A. D.	A district of Yüan (元) named Taoyüan. (桃源)
Kaoch'un	高淳	1371 A. D.	Originally a part of Lishui.
Kiangp'u	江浦	1376 A. D.	Established in consequence of the growth of sandbanks.
Chinshan	金山	1389 A. D.	First a fort. Became a district in 1724.
Chingkiang	靖江	1471 A. D.	Originally an island in the Yangtse near S. side of the river.
T'aits'ang	太倉	1497 A. D.	A granary with the port at Liuchiachiang. (劉家港)

§. According to a paper, "Some Notes on the History of old Shanghai" read before the Royal Asiatic Society (N. China Branch) on Feb. 17, 1916, Shanghai was supposed to have existed as a distinct city in 221 B.C. This is certainly erroneous. The year 221 B.C. was the beginning of the Ch'in dynasty. None of the districts established at the time can be identified with Shanghai or anywhere near it. The mistake, I think, arises from the fact that the local people always like to boast the antiquity of their city, and always put it down as once *formed a part* of the nearest ancient district. The tradition that Shanghai existed in 2,000 B.C. is of-course still more groundless.

Name.		*Date of Establishment.*	*Remarks.*
Paoshan	寶山	1724 A. D.	Originally part of Chiating.
Fenghsien Nanhui	奉賢 南滙	1724 A. D.	Part of Sungkiang with additional sandbanks.
Funing	阜寧	1731 A. D.	
Tungt'ai	東台	1767 A. D.	
Ch'uansha	川沙	1806 A. D.	Reclaimed land.
Yangchung 揚中=T'aiping		1806 A. D.	Island in Yangtse.



Fig. 28.—Map showing the dates of establishment of the cities in the Yangtse delta. The shaded area is supposed to have been added in historical time.

(2) THOSE DISTRICTS IN CHEKIANG BETWEEN THE RAILWAY AND THE SEA.

Name.	*Date of Establishment.*	*Remarks.*
Ch'ient'ang 錢塘=Hangchow	221 B. C.	A district of Ch'in of the same name.
Chiahsing 嘉興	221 B. C.	A district of Ch'in named Yuch'üan (由拳).
Haiyen 海鹽	221 B. C.	A district of Ch'in of the same name.
Haining 海寧	220 A. D.	A district of Wu named Yenkuang (鹽官).
Ch'ungtê 崇德=Shihmên	936 A. D.	Ch'ungtê was the original name
T'unghsiang 桐鄉	1430 A. D.	Ming (明) districts.
Chiashan 嘉善	,, ,,	
Pingh'u 平湖	,, ,,	

ANALYSIS AND INTERPRETATION :

If we draw a N.-S. line from the north of Kiangsu through the district of Tungt'ai, and then prolong it to the S.E. through T'ait'sang, Chiashan and south to the sea, we see that all the cities to the east of this line were established after the 5th century A.D. Out of the 34 cities established in the Christian era, 18 are to the east of that line. On the other hand, of the 49 cities west of the line only 17 are dated after the 3rd century A.D. ; all the other cities go back to 200 years B.C.

Now let us consider the factors that control the establishment of new districts; either there is an improvement in the administration, or the population must have been greatly increased. We cannot attribute the creation of all the new districts to the former cause, because, even as early as 205 B.C., 32 district cities out of the present 49 were already in existence west of the Tungt'ai–T'aits'ang line, and these are crowded in a comparatively small area. Most of the remaining 17 districts established during the Christian era owe their origin to the reclamation of land from the lakes and the Yangtse River, for example, the districts Paoying, Chint'an, Liyang, Wukiang, Hsinghua, Kaoch'un, and Ssüyang were built up gradually as

the lake basins decreased in area, and the districts Yicheng, Kiangp'u, Chingkiang, T'aihsing and Yangchung came into existence owing to local additions of sandbanks from the Yangtse; only a very few were due to administrative convenience in consequence of the establishment of the Grand Canal as a means of communication. So we are forced to come to the conclusion that if the area east of the Tungt'ai—T'aits'ang line had been populated to any extent before the Christian era, there would have existed at least some administrative units in that time. The complete absence of such units can only indicate the non-cultivation of land, and what could be the cause that prevented cultivation except that the land was not completely out of the sea?

Moreover it is rather remarkable that the date of establishment of the cities varies directly as the distance from the sea; those nearest to the sea are the most recent. We must not, of course, take the date of the establishment of a district as the date of its cultivation, which must have proceeded the former for sometime, but since there is no city older than the 5th century A.D. in the part east of the Tungt'ai-T'aits'ang line, we are justified in believing that it did not exist 4,000 years ago (See Fig. 29).

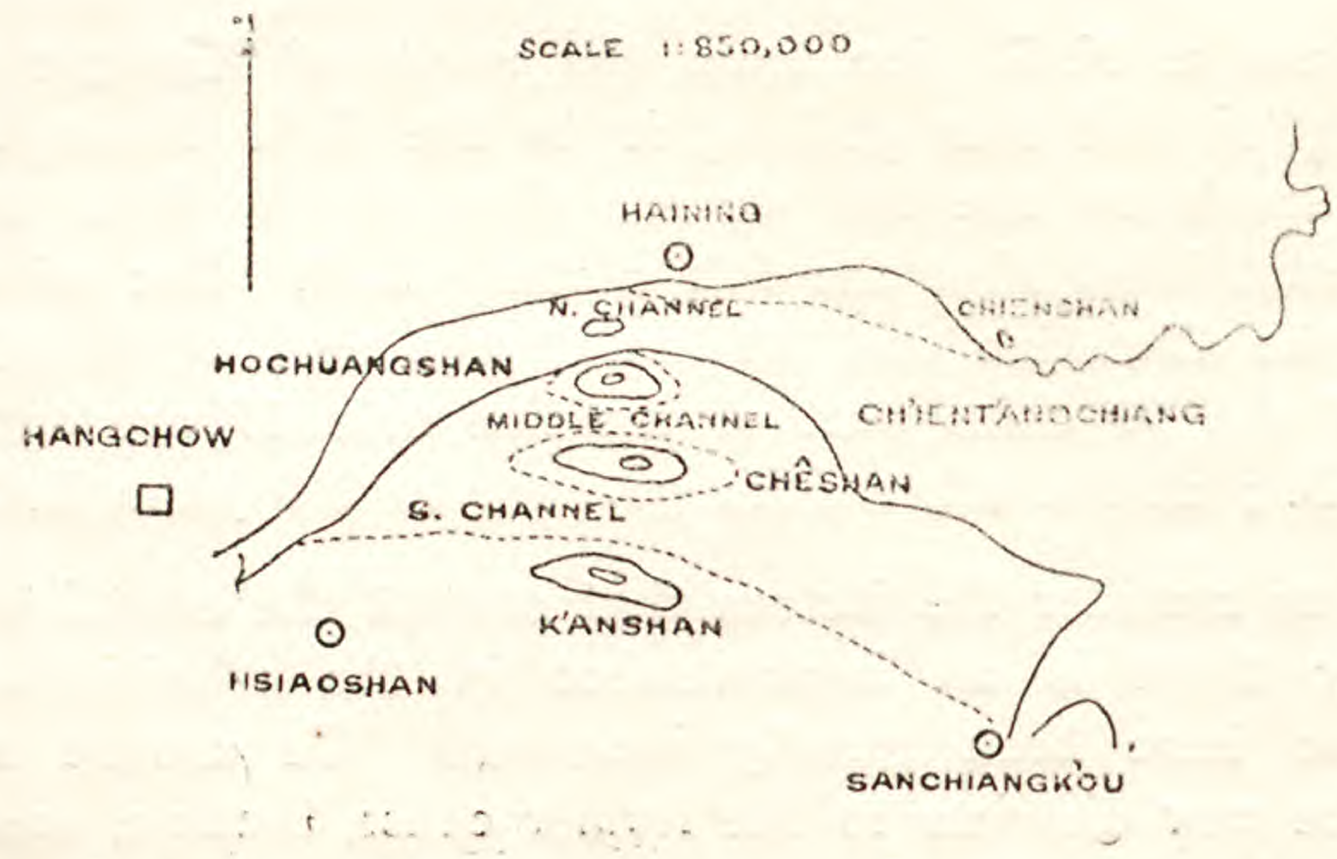


Fig. 29.—Map showing changes in the Chientangkiang.

The Dotted Lines show outline of former land.

ADDITIONAL EVIDENCES :

Additional evidence is not wanting. The classical case of Ch'ungming and the neighbouring district of Haimen have already been described in detail by Mr. von Heidenstam in the "Yangtse Estuary".§ The latter is believed to have appeared first in 200 B. C., but the former came into existence only in 620 A. D., and in less than 1,300 years sufficient land has been built up to support a population of three million souls.

The city of Ch'angshu, now 250 li from salt water, was, from the time of the 1st century A. D. to 283, the seat of the salt administration, hence the coast must have been much nearer to that city at the time. Again, as late as the 13th century, the port of Shanghai was not considered to be anything at all important; the main port for the sea going vessels was Liuchiachiang in the district of T'aits'ang to the east of Paoshan. Not only that ships coming from T'aits'ang loaded with rice and grain used to transfer their cargo there into the sea-going vessels, but it seems that considerable foreign trade was carried on, hence Liuchiachiang was known as the "Port of Six Nations". When we come to discuss the age of the Whangpoo, we shall see abundant proofs of its recent origin. It is also to be noticed that the conclusion arrived at here is in remarkable agreement with the estimates made by Mr. Heidenstam who thought that the coast line was at Kiangyin some 5,000 years ago.§§ Lastly, the known records of the sea dykes give interesting details, but the subject deserves a paragraph of its own.

THE SEA DYKES :

The sea dyke built along the coast of S. Kiangsu and N. Chekiang extends from Hangchow to the S. part of Ch'angshu opposite the Ch'ungming island. It is commonly supposed to have been built first in the T'ang dynasty, but according to the Records of Sungkiang in which the question was fully discussed, the age of the dykes is different in the different parts. Those in Chekiang are the oldest, as some of them certainly date back to the T'ang dynasty. The dykes in Kiangsu, on the other hand, are much more modern.

In fact, even in Chekiang, the dykes are not of the same age. The oldest part is that of Haining which was built before 713 A. D. when it was

§. p. 86.
§§. "Yangtse Estuary" p. 87.

repaired. Next come the Hangchow dykes which were built with difficulty by the famous Prince Ch'ienliu (錢鏐) in 910 A. D. It is somewhat uncertain whether the modern dykes coincide with the ancient sites. It is probable that the part between Hangchow and Haining has not been greatly altered, but the portion below Haining is now further inland owing to the changes of the Ch'ient'ang River. At the time when the dykes were built, the river between Hsiaoshan (蕭山) and Haining had three channels: the southern branch went between two hills of K'anshan (龕山) and Chêshan (赭山) from which the classical bore was best seen; the middle branch was between Chêshan and another hill called Hochuangshan (河莊山) and the northern branch, between the last and the present northern bank. Thus the southern bank followed a line N. of Hsiaoshan city along the N. foot of the hills to Sankiangk'ou. Now only one channel, the north branch, remains open, the other two branches have silted up and the islands joined together, so that a projection is formed opposite Haining, making the Ch'ient'ang much narrower, and the northern bank feels the pressure of the bore more than before. The silting up was practically completed by the beginning of the 18th century, and throughout the seven preceeding centuries, the northern bank suffered frequent inundations, and it was only by constant and strenuous effort that the dykes were kept in good repair.

The present dykes at Haiyen and part of P'inghu are comparatively modern, but other and more ancient dykes existed there. It is known that before the 11th century the sea was 95 li from the city of Haiyen, and there were eighteen parallel dykes to protect it. In spite of them the sea advanced steadily so that by the end of 13th century, the coast was only two li from the city. The distance was decreased to half a li in 1370. This rapid advance was only partially stopped by the repeated building of more massive stone dykes, the site of which probably coincides with that of 1381.

Although the sea dykes in Kiangsu are supposed by some writers to be originated from the T'ang dynasty, the existing dykes date only from 1472 A. D., the site of the old dykes being lost. These in Ch'angshu form an exception, for they were first built in 1754. There has been far less trouble and repair than in Chekiang.

The dykes at the Yangtse Cape in the district of Nanhui deserve special mention.§ The innermost dyke known as Laot'ang (老塘) was probably built in 1472. Constant addition of sand banks so increased the

§. "Yangtse Estuary" p. 88.

area under cultivation, that about 1590 A. D. the second dyke was erected to protect the newly established district city, which is situated on the very edge of the first dyke. The distance between the two dykes is about a mile which roughly represent the net gain from 1472 to 1590. The area outside the second dyke increased very rapidly since, and in 1884 a third dyke was built to enclose 300,000 mou of reclaimed land. Another dyke was built soon afterwards to strengthen the protection. The average distance between the second and the third dyke is about 5 miles, an enormous increase in 300 years! If we divide the distance between the first and the third dyke (i.e., 6 miles) by the number of years from 1472 to 1884, it would give a rate of a mile in 69 years, which figure is in wonderful agreement with that of Mr. Heidenstam §. who estimated it to be 1 mile in 60 years.

SOME IMPORTANT ADDITIONS ON THE YANGTSE BANKS:

Although it is quite certain that the Yangtse has not changed its course in historical time, lateral erosion and deposition have been constantly taking place and some important districts have been formed by this process. The cases of Ch'ungming and Haimen are very interesting examples. This process is by no means confined to the river mouth. Two other instances at least are well-known. The district of Chingkiang was originally an island near the southern bank called Matosha (馬馱沙) which appeared probably first in the 10th century A. D. and belonged to the district of Kiangyin. The northern channel rapidly silted up, and the island was joined to the northern bank, being separated from the mainland only by a small river which still forms the boundary of the new districts created in 1471. Before the Republican era, Chingkiang belonged still to the prefecture of Ch'angchow, although geographically it is much more easily reached from Yangchow or T'ungchow, as it is on the same side of the river.

Another example is that of Yangchung, which is still an island between Chinkiang and T'aihsing. It is uncertain when it first appeared, but it must be in any case quite recent. It used to be administered by several districts from which the population was drawn, but in 1906, it was created a "T'ing" and formed an administrative unit of its own.

It is to be noticed that these districts are all situated at a bend and on its inner side; this is in strict conformity with the rule that in

§. "Yangtse Estuary" p. 89.

a winding river the inner side of the curve is always a point of deposition. The district of Yicheng (儀徵) Kiangp'u and T'aihsing came into independent existence owing also to additions of sand banks from the river, but conditions have considerably changed since then and some of them, for example, Kiangp'u, are now losing land instead of gaining.

One interesting result of these changes is the irregularity in the distribution of dialects. As every one knows, there are two dialects in Kiangsu, the northern or mandarin, and the southern or Ningp'o dialect. The differences between the two are very considerable and is undoubtedly due originally to some difference in race. One would expect therefore that the boundary would follow some natural geographical line. At present the distribution seems to be inexplicable, for the boundary line is not formed by the Yangtse River, but the districts of Haimen and Chingkiang, both situated on the northern bank, speak the southern dialect, whilst T'ungchow has something between the two. The fact is now easily understood from the history of the districts; they were originally islands in the Yangtse, probably nearer to the southern bank whence they were first colonised, so they retain to this day their former language. Further west the division between the two dialects follows approximately the mountain range, so that Nanking and Chinkiang speak already the northern dialect, but the districts of Chüyüng and Lishui are intermediate; the southern portion of these two districts has a distinctly southern tone. Thence the boundary of the dialects coincides strictly with the boundary between Kiangsu and Anhwei, and with that between the latter and Chekiang. The southwest limit is significant, as it was the boundary between the two ancient kingdoms of Ch'u and Wu.

Origin of the Whangpoo River.

INTRODUCTION :

The Whangpoo river is, as we know it today, an important outlet for the T'aihu Lake and its head waters; it has a width of half a mile at its mouth and a discharging capacity of more than 6,000 cubic feet per second or 250,000 cubic feet per second including tidal current. But what is the origin of the river? Is it merely an artificial canal subsequently enlarged by tidal erosion, or is it a beheaded branch of the mighty Kiang in ancient time? Or again, has it always been such an important outlet for the T'aihu as it is? To answer such questions it is necessary to know: (1) the movement of the

coast relative to the sea, (2) the age of the delta, (3) the nature of the ground through which the Middle Kiang is supposed to have come through, (4) the origin of the T'aihu Lake, (5) the history of its outlets, and (6) the known facts about the Whangpoo in the written local records.

It is convenient here to sum up what we have already discussed, and consider the facts in relation to the question in hand. We have seen in the section on physiography that the coast has been sinking in recent geological history, but, of late, the movement has become either stopped or so slackened that it does not affect the power of deposition of the Yangtse River. In the present section we have seen further, that, from historical evidence, we know that the delta is surprisingly young. Again the only possible gap through which the Middle Kiang could have come to the T'aihu lake is found to be a low but real watershed formed by loess hills, but it is suggested that a branch of the Yangtse might have come off below Chinkiang. From these facts therefore we know that the Whangpoo is of very recent origin, and can not be the Middle Kiang of Richthofen. But how it was formed is a question which can only be answered when we have considered the origin of the T'aihu and the history of its outlets.

THE ORIGIN OF THE T'AIHU :

The T'aihu differs from the other large lakes of Kiangsu in the fact that it is not only very near to the mountains, but in the lake itself there are numerous rocky islands numbering some 90 in all. We have seen, in the section on structural geology, important faults traverse the lake in the direction N.E.—S.W. It looks therefore rather like a lake of tectonic origin. Again, its water is deeper on the average than the other lakes of Kiangsu, though unfortunately no accurate information about its depth is at hand. On the other hand there are many facts which indicate that the lake was once in communication with the sea. Let us consider them in some detail.

First of all there seems to be no great difference between the level of the lake and that of the sea. According to Mr. Heidenstam the mean sea level for the China coast is about 4 ft. above the Woosung Horizontal Zero. Now the mean level of the Hsit'ai (西台) lake, which is the nearest point to the T'aihu where the exact water level has been determined, is rather less than 8 feet § referred to the same zero, so the Hsit'ai lake is

§ Average of "half tide" level in June and October, 1915, given in "Hydrography of Whangpoo" page 52.

less than 4 feet above the mean level of the sea. The maximum difference of "half tide" levels for 1915 is rather more than a foot (1.15). The mean water level at Woosung is slightly more than 3 feet above the mean sea level, because "the annual resultant wind is N.E. and there is a coastward up gradient due to the enormous fresh water discharge." It seems to me quite justified to consider the Hsit'ai lake as originally at sea level—the present slight difference may be due to wind and current, and the relative amount of discharge and supply, since the lake has a rather restricted outlet. As the T'aihu is in free communication with the Hsit'ai, its level cannot be very different, and we can therefore state with some certainty that the T'aihu was originally at sea level.

We shall see when we come to consider the history of the outlets that they have been always on the east side of the lake. On that side there is nothing but recent alluvium between it and the sea, and, when we take the extremely small age of the delta into account, it is clear that the T'aihu must have been a part of the sea before the outer bars were formed. We may briefly reconstruct its history in supposing that an irregular basin was formed by faulting on both the N.E. and the west side in late Tertiary time, when most of the tectonic movements took place. Subsidence of the coast came in, and the whole was then in direct communication with the open sea, but as the deposition of sediments from the Yangtse mouth increased in extent, irregular bars were formed enclosing a kind of lagoon. This lagoon gradually became fresh and a lake was formed. Its original area must have been much larger, as most of the swampy land to the east and N.E. as well as the lakes of Ihsing and Liyang were parts of the same lake. The latter became separated, probably owing to some branch from the Yangtse which formed a barrier right across, and the former was silted up by tidal water and reclamation. Thus the T'aihu, in common with other lakes of Kiangsu, was originally a lagoon, the difference being that there was a tectonic basin before general sinking of the land took place.

HISTORY OF THE OUTLETS :

The T'aihu has all its outlets on the east side. (Fig. 30.) These are situated between the village of Chiuch'i (韭溪), 15 li N.W.N. to the point from which the Grand Canal gives off a branch to Huchow, and the port of T'ungk'êng (銅坑) 40 li W. of Soochow. They may be divided into three



Fig. 30.—Map showing the outlets of Taihu.

Scale 1 : 360,000.

groups according to the channel they follow further east. The first group consists mainly of five channels all going into the Grand Canal near the city of Soochow, whence they flow to the river Louho (婁河) or Loukiang that passes through K'unshan and T'aits'ang and empties into the Yangtse at Liuchiaho. These are known as the T'ungk'êng, Hsük'ou, Tachük'ou, (大缺口) Shihhu (石湖) and Nienyük'ou (黏魚口). The second group consists of two principal branches; the one north, and the other south of Wukiang. The former passes through the bridge of Kuaching (瓜涇) into a river that is regarded as the upper part of Soochow Creek, and the latter passes through the Changchiao (長橋) and the Fouyüchiao (浮玉橋) bridge into the lake of Pangshanho (龐山湖) and ultimately also to the Soochow Creek. The last group has now only two main channels, the Tapu'k'ou (大浦口) which passes directly into the pools and lakes to the east, and the Chiuch'ik'ou (韭溪口) which goes to the Grand Canal and passes through the Pingwang (平望) bridge to the lakes W. of the Tienshan (澱山) or Hsit'ai lake. Thus considered from the point of view of outlet there are three in number, namely the Louho, the Soochow Creek or Wusungkiang and the Tienshanhu or Hsit'ai lake which forms the head water of Whangpoo. These three are in communication with each other through numerous cross canals, and the Louho is also connected, through

the northern lakes, with the Yangtse before reaching its mouth, but there is practically no water that is discharged through these; the greater part of it goes south first into the Soochow Creek and then to the Tienshanhu, so that the Whangpoo forms the major channel of discharge, for, although the Soochow Creek and the Louho still share a portion of the outflowing water, their capacity is very limited, especially the latter.

These outlets however have not always had the same relative importance as they have today. I have already noted in connection with the age of the delta, that the port of Liuchiachiang situated at the mouth of the Louho was quite an important city of trade a few centuries ago, and from this we may suppose that the Louho was then more effective as a discharging channel. But it is above all the Soochow Creek or Wusungkiang that has always been regarded by all Chinese writers as the most important outlet of the T'aihu. According to the Records of Shanghai, this river had a width of 20 li at its mouth in the middle of the T'ang dynasty (8th century) and became gradually narrowed down to one li in the time of Sung (10th to 13th century). This seems to be an exaggeration, unless the coast line was much further to the west and the Soochow Creek was something of an independent estuary. There can be no doubt however that it was an important and impressive river. The connection between it and the T'aihu was also much wider, especially the channel S. of Wukiang known as Wuchiachiang, (吳家港) for, in the year 1045 when the famous long bridge south of Wukiang was built, this branch was quite free and wide so that the bridge had to have the enormous length of 400 M. with 64 arches to allow the water to pass through. The part south of Wuchiachiang had more than a dozen outlets into the pools and lakes in the east, of which only a very few now remain open. The Tienshanhu and its neighbouring lakes were then, as they are now, important reservoirs, but much of the water seems to have been discharged northwards into the Soochow Creek. The decay of the last named river began as its mouth became further from the sea, and, to make things worse, the supply of fresh water from T'aihu was greatly hindered by the construction of the embankment of the Grand Canal which was built in the middle of the 11th century to enable the boatman to tow boats along. From the pagoda at the south end of the Changchiao or Long Bridge to the point where the Grand Canal divides into two branches, 13 openings were provided for the water to pass out to the east, but most of them soon became blocked up by silt. Frequent floods then occurred, and a permament disaster was only avoided by increasing the discharging capacity of Whangpoo.

CONCLUSION :

The name of Whangpoo is unknown in Chinese literature before the 14th century, and the channel from Wusung to Shanghai has been always regarded as the lower part of the Wusungkiang or Soochow Creek. In the section on the ancient mouths of the Yangtse, we have seen that some Chinese writers supposed that, besides the Loukiang and Wusungkiang, the T'aihu had a more southernly outlet called Tungkiang, which was said to reach the sea independently. The existence of such a river had been disputed, but some modern writers think that the Whangpoo which had originally an independent mouth to the sea south of Sungkiang, is to be identified with the Tungkiang. Now it is immaterial whether the river is the same as the particular river mentioned by certain writers in a certain work, but it is important to know that it had a different outlet to the sea. This seems to be well established by the records of Shanghai §. which states that in the year 1404, Hsiayüanchi (夏原吉) a High Commissioner, put the river into free communication with Shanghai by making a canal at Fanchiapang (范家浜). I have not been able to identify the place on any Chinese map, but it is evidently somewhere between Shanghai and Sungkiang.

From the above considerations we may reconstruct the history of the Whangpoo somewhat as follows. The swampy areas east of T'aihu extended much further to the east when the T'aihu was first formed. These at first consist of a number of large shallow lagoon-like lakes which, when gradually being silted up, became a series of more or less connected pools of water; the outermost one was in communication with the sea just south of Sungkiang. As it was not a well banked channel of flowing water, no definite name was given to it, and the Soochow Creek remained the only important river recognised as such. About the time of the formation of the island of Ch'ungming, the area now known as P'ootung began to be formed as a sand bar, which enclosed a channel of tidal water to the west, into which both the Soochow Creek and the original southern pools discharged their water. At first the former was a more important river as it received the

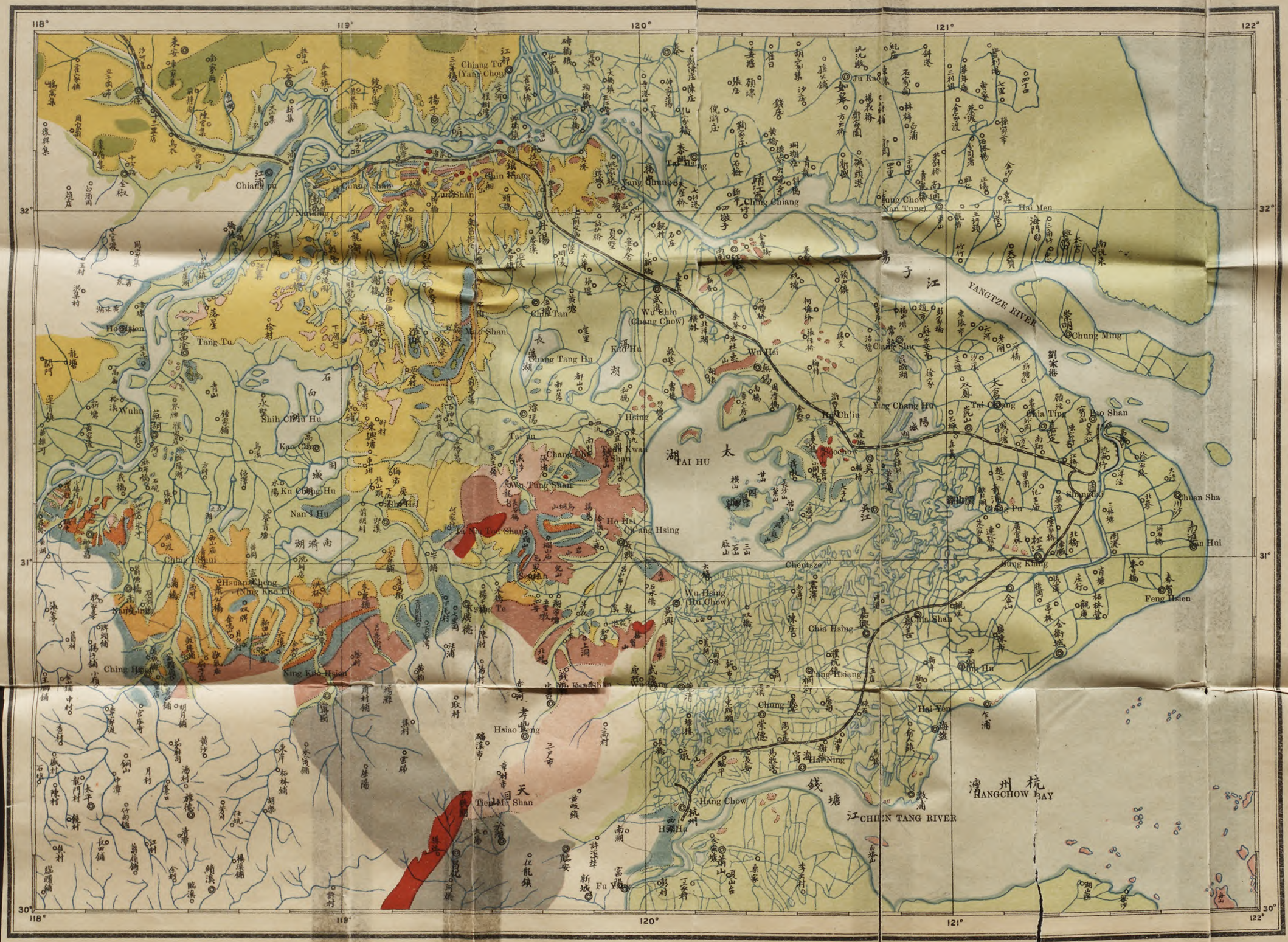
§. Opinions differ as to the exact spot where the Whangpoo emptied itself independently into the sea before the 15th century; but the different editions of the Records of Shanghai agree that its connection with Shanghai began in 1404. The original memorandum presented to the Emperor by Hsiayüanchi says as follows: –"The Great Whangpoo at Sungkiang is an important passage to the Wusungkiang but the lower part has been completely choked up with silt. I have found by its side a stream, called Fanchiapang, through which it can reach the sea directly. Therefore it should be enlarged to receive the Whangpoo." It seems that a connection already existed between the upper Whangpoo and Wusung, but the ancient channel had been silted up and Hsiayüanchi merely enlarged the side channel of Fanchiapang to restore the connection. The wording is however somewhat ambiguous.

major part of the water from T'aihu, but as its mouth became choked up with silt brought up by tide, and its connection with T'aihu narrowed and hindered, the greater part of the water flowed more and more into the low area to the south, the Tienshanhu and its neighbouring basins. This change brought about two things; firstly, the increase of volume of water gave the Whangpoo river more scouring power so that it was able to keep open its connection with the newly formed tidal channel between Sunkiang and Woosung, and secondly, the attention of the conservancy authorities began to be attracted by it, as the possibility of making it serve the purpose of the old Wusungkiang became apparent. Hence artificial enlargement and dredging were carried out in the 15th century and the Whangpoo, helped by tidal action and artificial work of conservancy, henceforth became the only important outlet for the T'aihu and its head waters. Thus we regard the present Whangpoo river as formed by 3 different portions: (1) the port above Sungkiang which was a series of connected pools of water, remnants of more extensive lagoons, that gradually dried up into a narrower river-like channel, (2) the part below Sungkiang, a tidal channel left between the old shore and the newly formed sand bank of Pootung, (3) the part between (1) and (2) partly natural, but enlarged by the hands of man, especially in the 15th century.

V. K. TING.

GEOLOGICAL MAP OF THE YANGTZE VALLEY BELOW WUHU BY V. K. TING AND L. F. YIH

Scale 1:1,000,000



LEGEND

PLATE NO. I